University of Cape Town Graduate School of Business
Department of Commerce

The observing self as a catalyst for behaviour change and wellbeing

Effective personal informatics system design
to promote behaviour change in the changing health paradigm

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Submitted in fulfilment of the requirements for the degree of

Master of Philosophy Specialising in Inclusive Innovation

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ABSTRACT

The current study is a user-centred enquiry into how wellness-related personal informatics (PI) systems can be more effectively designed to better promote lasting behaviour change and sustained wellbeing in the context of the changing health paradigm.

Until recently, the Western biomedical model with its disease focus has been effective in delivering health care; however, this paradigm does not efficiently support a system in crises – the contemporary health care system which is confronted with complex challenges of modern lifestyle diseases and behavioural disorders.

Enabled by the technological revolution, a Systems Medicine model – a preventative, personalised, predictive and participatory (P4) approach – is emerging and PI systems play a significant role in realising this pre-clinical, patient-centric, behaviour-focussed shift in health care. This viewpoint paper argues that design strategies applied in PI systems to promote behaviour change play a vital role in supporting health outcomes, specifically, persuasive and mindful user experience (UX) strategies.

By applying a phenomenographic research methodology, a user-centred approach is taken to understand qualitatively different ways in which PI systems (and their inherent design strategies) are experienced by users, to inform more intuitive design of PI systems that balance behaviour change strategies to support more lasting shifts and sustainable states of wellbeing. Drawing together ideas from systems medicine, complexity theory, persuasive and mindful design approaches in conjunction with phenomenography, this study aims to understand experiential nuances to offer implications for the future design of health care through PI systems.

The theory built through the research process is applied in a prototype design, which is presented as an example of a PI system design that balances persuasive and mindful strategies and aims to promote lasting behaviour change and enduring states of wellbeing more effectively.

KEYWORDS: Personal Informatics, Systems Medicine, user experience, positive technology, persuasive technology, mindful / reflective technology, behaviour change, wellbeing.

ACKNOWLEDGEMENTS

I would like to express gratitude to the many people who generously contributed to the work presented in this dissertation.

I thank my supervisor, Dr Jonathan Marks, not only for his academic guidance throughout this uncharted journey, but also for his genuine interest in the topic and for enabling many valuable opportunities through his network.

A special mention goes to Julie Deane-Williams, especially for indirectly inspiring the research direction and for sharing her work in mindfulness-based therapeutic dietetics with me.

Sincere appreciation goes to Karen Johnson, Craig Nossel and members of the strategic programmes and wellness departments at Discovery Vitality, who allowed me to spend time immersed in their space to gain a better practical understanding from the perspective of an organisation that is widely regarded as a global innovator in this emerging field.

I also owe gratitude to those nearest me, to whom I dedicate this thesis: my parents, for their unfailing support and continuous encouragement, allowing me to embrace this opportunity for growth; and the rest of my family, past and present, whose academic achievements offer endless aspiration.

And to Guy, whose ever-urgent pursuit of expanding knowledge and understanding, inspires me to stay curious.

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1 INTRODUCTION

This study is a user-centred enquiry into how wellness-related personal informatics (PI) systems can be more effectively designed to better promote lasting behaviour change and sustained wellbeing in the context of the changing health paradigm. A phenomenographic research methodology is applied to provide a human-centred lens to qualitatively different ways in which people experience – perceive, engage with, conceptualise and respond to – various behaviour change strategies as applied in popular PI system design that aims to promote wellbeing.

The changing health paradigm, characterised by a systems medicine approach that is preventative, personalised, predictive and participatory (P4), is being accelerated by the plethora of innovative tools of the digital revolution, including wellness-related PI systems. This health care approach aims to improve the efficiency and sustainability of the health care system and to reduce resources required for treatment and recovery. It further places the whole person at the centre of his/her health, shifting greater responsibility from health care system to the individual, thus emphasising participatory practices through PI systems. Consequently, PI systems that promote related activities are playing an increasingly vital role as an interface between users (patients and consumers) and the health of their bodies and minds, and the greater health care system, including providers (e.g. physicians, therapists and care-givers) and payers (e.g. health insurers and public health), emphasising the importance of considered and responsible system design practices.

Thus far, interest has predominantly focussed on how PI systems and the data they generate can be used by institutions to better understand and influence consumer behaviour, while far less human- (user-) centred research has been conducted to understand how people use, experience and respond to PI systems and the behaviour change strategies embedded in their design.

Recent literature has revealed that various behaviour-change design strategies are employed by PI system designers to nudge users towards healthier behaviour and habits. These strategies are broadly categorised as persuasive (which includes behavioural economics insights) and mindful (also referred to as reflective) design tactics, both of which are effective

in motivating behavioural change; however, the ways differ in which users engage cognitively. These strategies play a powerful role in informing participatory health practices, effecting longevity of behavioural change and resulting wellbeing.

The current study therefore reveals qualitatively different ways in which respondents engage with wellness-related PI systems and the interplay between persuasive (including behavioural economics) and reflective (mindful) strategies surfaces throughout this process – to inform better system design to ultimately provide a catalyst for more lasting behaviour change and sustained states of wellbeing.

The theory developed throughout the research process is applied in a prototype design, which is presented as an example of a PI system design that balances persuasive and mindful strategies, aiming to promote lasting behaviour change and sustained wellbeing more effectively.

1.1 Context

Many of the challenges we face as a global population are rooted in the compromised behavioural health of individuals. Behavioural health relies on people to make decisions and act in ways that promote personal and collective wellbeing, and on individuals to be cognisant of choices and actions (Pagnini & Philips, 2015).

The global economic crisis is forcing health care organisations to balance declining resources with increased health care costs, calling for a new business and treatment model characterised by a shift from a disease-centred paradigm to a more complex participatory paradigm (Graffigna, Barello, Wiederhold, Bosio & Riva, 2013).

The responsibility of resolving the health consequences of compromised behaviour falls on the healthcare sector, which has evolved as a biomedical model with the primary focus on treating illness. The changing paradigm in health is shifting focus to prevention of illness and emphasises management of wellbeing through daily lifestyle adaptations.

According to Mulgan (2006), innovation deficits exist in addressing behavioural problems. Two models exist for understanding and influencing human behaviour, i.e. the cognitive and the context models (Dolan, et al., 2012). These two approaches are founded on two distinct 'systems' operating in the brain that have been identified by behavioural scientists, psychologists and neuroscientists: System 1 and System 2 (Kahneman, 2011).

The cognitive model is based on influencing what people rationally (mindfully) think about. The premise is that an individual analyses the benefit of a particular decision and then behaves in ways that support the best outcome. Behaviour is influenced by 'changing minds', through conscious reflection on the surrounding environment, also referred to as 'System 2' thinking processes (Kahneman, 2011). Mindfulness approaches are increasingly being adopted to support cognitive models for understanding and influencing behaviour (Kabat-Zinn, 2003; Langer, 2000; Siegel, 2009a).

The contrasting context model reflects behavioural economics theory (Ariely, 2009; Dolan, et al., 2012; Kahneman, 2011; Thaler & Sunstein, 2008) and focuses on more automatic processes of judgement and influence and the ways in which people respond to the environment. It recognises that people are frequently irrational and inconsistent in their choices, often due to external influences and 'System 1' thinking processes (Kahneman, 2011), which shift the focus of attention away from facts and information and towards the context or situation within which people act.

Behavioural economics is increasingly being adopted in policy setting, and specifically in the design of behavioural change intervention, centered around this context model (Dolan, et al., 2012). This has given rise to the concept of choice architecture, which refers to the design of systems and environments (actual and virtual/online and offline) that are designed to nudge people toward desired behaviours based on specific behavioural economics insights and System 1 processes (Thaler & Sunstein, 2008).

System 1, the 'automatic mind', is uncontrolled, effortless, associative, fast, unconscious and often irrational or mind***less*** and responds to context models of behaviour change. System 2, the 'reflective mind', is controlled, effortful, rule-based, slow, conscious and rational or mind***ful***, offering more systematic, rational and 'deeper' analysis, and responds to cognitive models of behavioural change. However, System 2 has limited capacity. Furthermore,

maladaptive behavioural problems are exacerbated by depletion of System 2. (Baumeister, Sparks, Stillman, & Vohs, 2008; Kahneman, 2011).

Depletion refers to a concept from behavioural economics that refers in turn to one's likelihood to engage in reactive, irrational behaviour due to factors such as stress, tiredness and feeling overwhelmed. Depletion is prevalent across population segments, from the poor for whom daily survival is a struggle due to obvious resource shortages, to executives who deal with professional pressures and constraints such as time (Ariely, 2009; Hick & Furlotte, 2010; Langer, 2000). The behavioural symptoms of depletion generally stem from complex personal and systemic challenges, which make it difficult to address by traditional approaches and models of treatment (Mulgan, 2006).

The ancient practice of mindfulness is increasingly being supported by evidence as a way to promote wellbeing and integration in our minds, bodies, as well as in our relationships (Kabat-Zinn, 2013; Langer, 2000; Siegel, 2010). Though many definitions exist, mindfulness is a quality or state of awareness and attention. Kabat-Zinn (2013) describes mindfulness as paying attention in a purposeful manner, in the present moment, and non-judgmentally. It is further defined by Langer (1992, p. 289) as "a state of conscious awareness in which the individual is implicitly aware of the context and content of information. A state of openness to novelty in which the individual actively constructs categories and distinctions". Siegel (2015) draws on neuroscience to explain the neurobiological benefits and describes mindfulness as a form of intrapersonal attunement that alters the experience of the self, promoting integration, enabling greater equilibrium internally and more empathy interpersonally. Siegel further asserts that by changing how we see ourselves in the world, mindful awareness has the power to shift destructive patterns of thought and behaviour.

Yet, in our contemporary, polarised world – which is characterised by both excess and scarcity, flooding information, stimuli and choice – mindful awareness is a scarce resource, depletion of which creates personal and collective disintegration. Over 30 years of widespread scientific research have affirmed the importance of mindfulness and its benefits in improving health, wellbeing and quality of life, assisting people to avoid impulsive and undermining behaviours, caused by pre-existing or underlying habits and predispositions (Kabat-Zinn, 2013; Langer, 2000; Pagnini & Philips, 2015; Siegel, 2009b, 2015).

The shifting healthcare paradigm is leading to greater inclusion of patient involvement in healing and wellbeing – through all stages: diagnosis, treatment, healing and maintenance of wellbeing. This shift infers an increasing focus on attunement to the self through self-management of treatment and prevention. Thus, self-tracking and reflective practices are playing a more prominent role in the pursuit for wellbeing (Dubberly, Mehta, Evenson & Pangaro, 2010). In this context, reflection through self-tracking by means of PI systems is framed as a practice that promotes mindful awareness as it draws users' attention to present senses, experiences and behaviour, facilitating intrapersonal attunement and therefore has the potential to strengthen System 2 processes.

Self-tracking of any kind of biological, physical, behavioural, or environmental information is defined by the term 'Quantified Self' (QS). QS is recognised as a prominent trend emerging in big data science and personal health and wellbeing (Swan, 2013). The QS movement has grown exponentially in parallel with the surge in PI systems.

The biopsychosocial, Systems Medicine shift is being influenced and catalysed by the convergence of science, philosophy, information technology and engineering – more specifically, Internet of Things (IoT) products, Big Data and related personal informatics systems. Examples include activity trackers, medical sensor prototypes, electronic healthcare record databases, clinical genome browsers, consumer personalised medicine, health social networks and various QS-tracking platforms (Bui & Zorzi, 2011; Chin, 2000; Swan, 2009).

However, the plethora of PI systems – web services, applications and devices – skillfully designed to collect personal data by tracking everything from strides taken per day, to calorie consumption, to more subjective 'measurables' such as sleep quality and mood, presents its own challenges.

For example, keeping track and making sense of streams of personal data can be perplexing and overwhelming, particularly in the context of the prevailing 'attention economy' characterised by information overload, which depletes human attention and compromises behaviour (Duval, 2011). It is therefore imperative to apply responsible system and user experience design strategies and to serve data to users in ways that are accessible, meaningful, and actionable.

Furthermore, personal data is a highly sensitive, private and complex. The rise of big data and artificial intelligence holds concerns, specifically from perspectives of accuracy, privacy,

freedom and authenticity. Ethics and transparency are essential to earn and maintain high levels of trust in providers' brands and products. It could be argued that without a user-centred, values-based approach, user adoption, continued engagement, lasting behavioural shifts and positive wellness outcomes are simply not likely.

Thus, in order to design systems that offer real value – supporting lasting behaviour change and enduring states of wellbeing – the challenge lies in deciphering users' experiences with existing systems: their needs, beliefs, perceptions and behavioural responses. A deeper understanding of users' conceptions can lead to formulation of principles to guide system- and user-experience design strategies to promote behaviour change and wellbeing more effectively.

By understanding and harnessing principles of behavioural economics, mindfulness and intuitive user-interface design and applying collective insights to PI system design, product designers can support behaviour change that ultimately better promotes personal and collective wellbeing (Consolvo, Mcdonald, & Landay, 2009; Gao, 2012; Graffigna, et al., 2013; Marcengo & Rapp, 2013). The research conducted informs a prototype design that is presented in Chapter 7 to illustrate implications and application of the theory.

1.2 Research Problem

It is evident that the adoption of PI systems is playing an increasingly important role in behavioural interventions designed to prevent disease and promote wellbeing. These systems are progressively pervasive, specifically among higher income groups. Furthermore, as PI systems become more commonplace and affordable, uptake by broader audiences becomes more feasible and ubiquitous. The permeation of PI systems thus holds powerful potential to effect wellbeing and to adapt behaviour of broader populations, including the broader public health domain and more targeted at-risk segments. PI systems, when effectively designed, hold the potential to be a vital medium for improving wellbeing – ways of being of individuals, groups and communities to create a healthier culture.

However, as with any innovation, emerging phenomenon and new tool or method, there are often unexpected and unintended, systemic consequences and effects. A growing body of research emphasises complexity and concerns around behavioural interventions in general,

and specifically the use of PI systems and application of behaviour economic strategies to promote behaviour change and wellbeing (Etkin, 2014; Gao, 2012; Lupton, 2015; van Dijk, Beute, & Westerink, Joyce & Ijsselsteijn, 2015).

Thus, to inform responsible PI system design, which circumvents adverse effects and supports more lasting behaviour change and enduring states of wellbeing, an inclusive, user-centred approach is essential. A need thus exists for a deeper insight into users' experiences, their cognitive and behavioural responses, along with greater understanding of behaviour economic strategies and mindfulness principles in practice, to formulate implications and guidelines for responsible PI system design practices.

1.3 Research Questions

1.3.1 Primary Research Question

What are the qualitatively different ways in which people experience personal informatics system design that seek to promote behaviour change for improved wellbeing in the context of the changing health paradigm?

1.3.2 Secondary Research Question

How are established principles of behavioural economics and mindfulness applied and incorporated in the design and experience of personal informatics systems?

This study offers a user-centred enquiry into the qualitatively different ways in which PI systems are experienced by users and how these systems impact behaviour and affect wellbeing. The interplay between behavioural economics design strategies (forming part of a 'persuasive' technology categorisation) and reflective design strategies (which form part of a 'mindful' technology categorisation) is explored to inform strategies, which balance these approaches. This study aims to formulate guidelines to inform a more inclusive and reflective approach to PI system design, which aims to support more lasting behaviour change and enduring states of wellbeing.

To illustrate application of the theory, this approach is prototyped and applied to the design of a specialised and differentiated wellness brand and PI system, along with an inclusive business model, in response to qualified pain points in user experience, as well as evident gaps in the PI system market.

1.4 Chapter Summary

This current study contends that PI system design informs how, and the extent to which, user behaviour and wellbeing are altered, and has the potential to better support more enduring wellbeing and health outcomes. By connecting key concepts around the changing health paradigm, PI system user experience, behavioural economics (and persuasive technology) and mindfulness (and mindful technology), this study aims to understand the lived experience of the use of PI systems, of a sample group of users in South Africa, and to inform how these systems might be better designed to support lasting behaviour change for sustained wellbeing.

The current research focuses on users' experience of PI systems in relation to shifting behaviour to promote, manage and maintain wellbeing. It explores the influence that the design strategies applied in these systems has on users' self-awareness, decision-making, behaviour and ultimate wellbeing.

This chapter introduced the context of the study and outlined the research problem and questions centred on the importance of gaining a deep understanding of PI system user experiences, from the users' perspective. It also afforded insight in behaviour economic and mindfulness principles, to inform responsible system design that has the potential to promote more lasting behaviour change and enduring states of wellbeing.

Chapter 2 presents an explorative review of literature, investigating frameworks of inclusive innovation, the emerging health paradigm and key considerations for PI system design in this context.

Chapter 3 provides an outline of the research approach, as well as a phenomenographic research methodology, which seeks to explore the qualitatively different ways in which people experience a phenomenon and to draw upon these experiences to enhance and

improve current practice. Elements of grounded theory and action research have been applied to allow for a more rounded study that is grounded in a real-world context.

Chapter 4 discusses the research method, which includes surveys and semi-structured interviews with users of PI systems to reveal more about the lived experience of these systems.

The research results and findings are presented in Chapter 5 in the format of a phenomenographic outcomes space, revealing categories of description of the qualitatively different ways in which PI systems are experienced, along with structural themes.

Chapter 6 offers a discussion of insights yielded by the research findings and provides an exploration of the research findings through the lens of the literature in an attempt to answer the research questions and contribute to addressing the research problem. Limitations are outlined.

Implications of the research and application of the theory are presented in Chapter 7, with an adapted model to inform system design, a differentiated brand and product prototype design and an inclusive business model and business plan.

Chapter 8 concludes this research with a summary of the contribution of this study, suggestions for future research, and final thoughts.

2 LITERATURE REVIEW

2.1 Introduction

This chapter is a review of relevant literature, which explores existing concepts to contextualise key considerations for PI (Personal Informatics) system design. It is divided into five main sections, each discussing one of the key focus areas, starting with a broad description of the inclusive innovation theoretical framework, the role of technology and the combined relevance in the emerging health paradigm within this framework. The emerging health paradigm is then discussed in greater detail, followed by a discussion of the role of technology and personal informatics (PI) systems in this context. This is followed by an investigation of current academic concepts around persuasive and reflective technologies and their function in promotion of health and wellbeing, with reference to applications of behaviour modification strategies and the manner in which self-observation and mindfulness are encouraged by system design.

2.2 Inclusive Innovation

2.2.1 Overview

Innovation – defined as the design of novel concepts that change processes and structures, resulting in market-centric products and services that support business outcomes and economic growth (Baregheh, Rowley & Sambrook, 2009; Du Plessis, 2007) – has been shown to be essential to long-term organisational relevance, exploitation of new technologies and changing and dynamic markets (Baregheh, et al., 2009; Rogers, 1962; Schumpeter, 1934). Social innovation, a response to the inequality and sustainability challenges we face as a global society, has been extended into inclusive innovation, the process by which formerly disregarded groups are included in the innovation process through the principle of shared value creation in which potential audiences become active participants in the innovation process (Foster & Heeks, 2013; George, Mcgahan & Prabhu, 2012; Codagnone, 2009; Heeks, Amalia, Kintu & Shah, 2008).

Complexity science has emerged as a trans/interdisciplinary framework that offers an alternative to reductionist, mechanistic processes to addressing fundamental challenges in

complex and adaptive systems (CAS) – systems in which large numbers of components (agents) interact and evolve. It encompasses an array of systems approaches and is being adopted across domains, such as innovation, economics, ecology, information technology and health (Holland, 2006; Rogers, Medina, Rivera & Wiley, 2005) in order to:

- Encourage innovation in dynamic economies
- Provide for sustainable human growth
- Predict changes in global trade
- Understand markets
- Preserve ecosystems
- Control the Internet (e.g. controlling viruses and spam)
- Strengthen the immune system
- Address sustainability challenges of the current healthcare paradigm

(Holland, 2006).

2.2.2 The Need for Innovation in Healthcare

Against the backdrop of increasing healthcare costs, worsening outcomes, shortages of physicians and epidemics of lifestyle and environmental conditions, the current health care system is unsustainable (Borrell-Carrió, Suchman & Epstein, 2004; Engel, 1977; Gardner, Acharya & Yach, 2007; Hood, Balling & Auffray, 2012; McHattie, Cumming & French, 2014; Swan, 2012a). The current system has its roots in the 19th and 20th centuries and was developed at a time when the challenge of infectious diseases dominated health concerns. In recent times, this has given way to the prevalence of more complex epidemics, the result of the interplay of genetic predisposition, environmental context, lifestyle choices and personal behavioural factors of individuals, which now dominate the burden on the present health care system, which has not adapted sufficiently. This underpins the vital need for innovation in this domain (McHattie, et al., 2014; Plsek & Greenhalgh, 2001).

The current major causes of mortality under the age of 75 are dominated by lifestyle diseases, including chronic illnesses, such as cardiovascular and respiratory diseases, diabetes, and certain cancers, which account for 36 million of the annual 57 million deaths globally. These statistics are in stark contrast with figures from a century ago, when only 5% of deaths were

attributed to behavioural factors and infectious diseases accounted for most fatalities. These chronic conditions are exacerbated by behavioural factors, such as stress, obesity, inactivity and addictions. Many are preventable by addressing behavioural causes through promotion of healthy diets, regular physical activity, avoidance of tobacco use and excess alcohol/drug intake, and adherence to chronic disease medications (Gardner, et al., 2007; Halpern, et al., 2004; McHattie, et al., 2014).

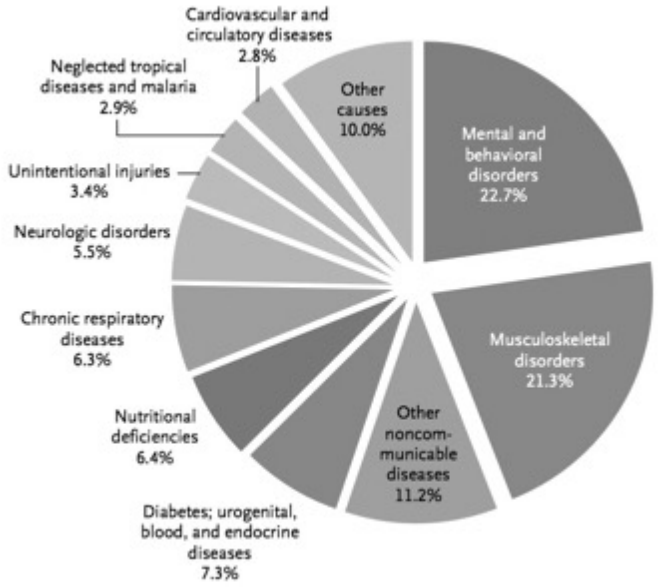


Figure 1: Global burden of years lived with disability, 2010 (Becker & Kleinman, 2013)

Figure 1 shows the global burden of years lived with disability due to mental and behavioural disorders, as compared with disability due to other highest-ranked categories of disorders and conditions. Furthermore, as indicated, 16,4% of the global burden of years lived with a disability is attributed to these largely preventable diseases (cardiovascular and respiratory diseases and diabetes). Even more staggering is the 22,7% of health-related drains on the global economy attributed to behavioural (and mental) disorders, far outweighing other health-related causes of global burden of years lived with disability. Large portions of these segments are comprised by lifestyle-related disorders, which are manageable with appropriate behavioural interventions. Behavioural factors further impact other segments, such as musculoskeletal disorders (contributing factors being lack of physical activity and stress), unintentional injuries (contributing factors being alcohol abuse and addictions) and nutritional deficiencies (Becker & Kleinman, 2013; Christie & Yach, 2015; Mulgan, 2006; Patel, 2015).

Severe innovation deficits exist in addressing these complex behavioural challenges (Mulgan, 2006). The future of health care thus requires development of systemic solutions directed towards personal choices that impact health risks (Dolan, et al., 2012; Halpern, et al., 2004; McHattie, et al., 2014; Mulgan, 2006).

2.2.3 Digital Innovation in Health Care

The upsurge in information and communication technologies (ICT) – industries that capture, transmit and display data electronically – plays a key role in emerging innovation systems, enabling the majority of new models of inclusive innovation. Many of these models leverage trends in big (and small) data (Botella, et al., 2012; Heeks, et al., 2013; Lupton, 2014; Swan, 2013).

These revolutionary digital technologies are leading to radical shifts in the delivery of health and wellness care, transforming traditional health care processes. The pervasiveness of ICT through mobile technologies, and their subsequent systemically embedded nature in people's lives, most notably through mobile phones, offers powerful potential for behavioural interventions. ICT interventions have the potential to combine a personalised approach of traditional individual interventions with more participatory and networked capabilities, while supporting unprecedented scalability with low marginal costs (Banos, et al., 2016; McHattie, et al., 2014; Tiago, Tiago, Amaral & Silva, 2016). Thus, linking powerful capacities of both technological and social innovation (in developing countries) represents the only sustainable means of improving the effectiveness of a health system in crisis (Gardner, et al., 2007).

Hence, policy makers, employers, organisations, and health care providers are embracing new ICTs to address systemic, behavioural health challenges in more dynamic and inclusive ways, through modes that demand active participation of individuals in personal health and lifestyle decisions. This emphasises the need for ongoing research and development of design approaches to gain deep understanding of systemic challenges – macro-structures (organisational) and micro-level behaviour (individual) – to support intelligent design of ICTs and the systems that they represent (Banos, et al., 2016; Becker & Kleinman, 2013; Christie & Yach, 2015; Gardner, et al., 2007; Halpern, et al., 2004; McHattie, et al., 2014).

2.2.4 Summary

This section introduced the inclusive innovation and CAS frameworks, and contextualised a key innovation mandate of the prevailing health care paradigm – a mandate that necessitates a shift from disease focus toward a systemic approach, one which is directed at behaviour and lifestyle management, to reduce the prevalence of chronic conditions by minimising individuals' health risks. Innovative ICT is presented as a pivotal medium to facilitate this shift. Finally, the need for deeper understanding of systemic challenges, opportunities and complexities in the current health domain, to inform innovative design approaches to development of ICT products and the systems that they represent, is emphasised as an imperative for the development of sustainable future care modes.

The following section will further explore the emerging health paradigm, a shift toward a systemic, preventative and participatory focus, accelerated by innovation in digital health technologies.

2.3 The Emerging Health Paradigm

2.3.1 Overview

Health care is inextricably interwoven with the ways in which we experience and find meaning in our world. Exploring the various facets of the theory and practice of health care over time – its disease and health concepts, research strategies and therapeutic approaches – reveals integral nuances of the human self through the system that man has been co-creating over the ages (Foss, 1994; Rose, 2007). This sub-chapter will explore approaches in health care through the lens of complexity thinking, starting with a description of aspects of complexity approaches, leading to a brief, historical, systems view of approaches in health care that have led up to the currently emerging paradigm, described as Systems or P4 Medicine, which is discussed in detail.

2.3.2 Complexity Thinking

The transdisciplinary field of Complexity Science is being applied to assist in understanding and harnessing the multi-layered reality of today's health care system. It encompasses various

theoretical frameworks, including Systems Theory (Luhmann, 1984; Rosnay, 1979; Von Bertalanffy, 1950), also referred to as Cybernetic Theory (Hayles, 1999; Wiener, 1961), Autopoietic Theory (Maturana & Varela, 1980; Zeleny, 1981). Complexity Theory (Plsek & Greenhalgh, 2001) and Biosemiotics (Sebeok, 1964).

These conceptual models are being applied to better understand behaviour of complex and adaptive systems (CAS) – the relationship between macro-structures (organisational) and micro-level behaviour (individual) of the system as they seek to explain the dynamic interplay of the compound processes, interactions, outcomes, accounts and events, including unintended consequences, that occur inextricably over time. Furthermore, a central topic of these theories is self-regulation or self-organisation in systems, self-correcting through communication or feedback to reach goals, adapt, maintain or restore equilibrium or homeostasis and evolve. Other important synergistic themes are communication, cooperation, specialisation, spatial and temporal organisation, and reproduction (Chandler, Rycroft-Malone, Hawkes & Noyes, 2016; Favareau, 2010; Foss, 1994; Hood, et al., 2012; Jones, 2015; McHattie, et al., 2014; Paina & Peters, 2012; Schwartz, 1982; Schwartz & Wiggins, 1986; Sharov, 2010; Sturmberg & Martin, 2014).

In cybernetic terms, a central principle is the idea that humans, animals, and machines do not operate as independent entities, but rather combine with one another and with the environments in which they exist to form complex systems of communication and structure. The functioning of biological organisms, ecological systems and advanced machines can further be understood through understanding how information is used to adapt to changing conditions in their environments, i.e. communication or feedback. The concept of 'feedback' refers to the idea that information about the results of past behaviour serves to modify future behaviour. As Wiener put it, "to act effectively, it is necessary that information concerning the results of [one's] actions be furnished as part of the information on which it must continue to act" (Wiener, 1954, p. 35). Feedback is the driver of all 'goal-directed' behaviour, whether it be conscious (as in the case of humans) or 'automatic' as in the case of much natural phenomena and many machines (Garland, 2007; Hayles, 1999, 2006; Jones, 2015; Wiener, 1954, 1961).

Applying a systems approach, the following section will thus provide temporal context of the emerging health paradigm by exploring aspects of the history of health care to provide insight into ontological shifts that embrace Complexity Science, accelerated by digital innovation.

2.3.3 The Biomedical Model

Biomedicine, also referred to as Western and modern medicine, has its roots in Hippocratic (+/-450-370 BC), Cartesian (1596–1650) and Newtonian (1643-1727) views, and emerged during the Scientific Revolution of the Age of Reason/Enlightenment (1685-1815), being further established during the Industrial Revolution (1760-1840). A reaction against the prevailing theocracy and religious epistemologies of health care, the thought world during this time was grounded in scientific advances and new confidence in empiricist approaches. Scientific reductionism, Cartesian dualism, mechanism and upward causation offered an "infrastructural rationalisation" for the development of the biomedical paradigm in which through detached, clinical observation the body was viewed "as a 'mindless' machine" (Foss, 2002, p. 37), an engine with pistons and pumps (Lupton, 2013b), with a primary focus on determining, treating or controlling causal, physical aspects of disease. The objective physical world is kept separate from the psyche (the inner space of the mind, emotions, cognitive processes and behaviour) as well as from its social context and environment (Borrell-Carrió, et al., 2004; Engel, 1980; Flores, Glusman, Brogaard, Price & Hood, 2013; Foss, 1994, 2002; Foucault, 2004; Kriel, 2015; Mazaza, 2015; McHattie, et al., 2014; Plsek & Greenhalgh, 2001).

From the end of the 18th century, as the biomedical paradigm gained success and impetus, medicine started to extend its essentially clinical disease focus to incorporate a social directive, as medicine and health became political and economic concerns. This is evident in the emergence of a medical authority or 'medicine of the state', and a new field of public health interventions, including air, water, construction, terrain and sewerage. Furthermore, during this period the first hospitals were introduced, whereas, preceding this, these institutions were not much more than a place for the poor to go to die. Mechanisms of medical administration, such as recording of data, collection and comparison of statistics, became part of an organised practice. However, other facets of management of the human

body, such as hygiene, diet and sexuality still fell outside of what was considered 'medicalisable' (Foucault, 2004).[1]

Succeeding the modern reductionist directive, throughout the course of the post-enlightenment 19th century, more complex 'post-modern' systems approaches started to develop in the Western thought world as physicists, mathematicians, chemists, and others searched for better 'infrastructural rationalisations' or explanatory models to describe and predict the behaviour of phenomena under study (Foss, 1994; Sturmberg & Martin, 2014; Wiener, 1954).

However, in medicine, the explosion of scientific discoveries perpetuated a mechanistic paradigm. The invention of the stethoscope by French physician René Laënnec in 1816 marked the beginning of the 'era of pathology detection by internal body signs', which was furthered by modern scientific developments in physiology, cellular pathology, and bacteriology. The process advanced further in the 20th century with the application of chemical analysis to diagnostics, the discovery of antibiotics and, later, ground-breaking technologies like ECG and MRI, along with development of powerful sciences of biochemistry, molecular cell biology, and genetics (Foss, 2002), which has paved the way for Systems Biology. However, modern medicine had firmly organised itself around the great success of the reductionist biomedical model, which had led to pivotal discoveries and laid the foundation for an extraordinary rise in diagnostic and therapeutic efficacy, establishing the biomedical approach as an enduring and prevailing paradigm, institutionalising the contemporary medical culture over time (Engel, 1977; Foss, 2002; Strum, An, Segal & Patel, 2013).

2.3.4 Early Systems Approaches in Medicine

Towards a new medical ontology

Since the mid-20th century, a growing body of research has been interrogating the cogency of the prevailing biomedical model, enquiring whether it meets the two conditions essential for any viable scientific model:

[1] Neoliberalist ideals entrust individuals with these responsibilities, with Libertarian Paternalistic assistance (Foucault, 2004; Thaler & Sunstein, 2008).

- Does it account for the full range of findings in the experimental literature?
- Do its fundamental premises align with more basic sciences (on which the applied science of medicine relies for validity) regarding, for example, the behaviour of matter, specifically complex systems (like patients), and broader scientific explanation?

Concluding that the dominant paradigm falls short on both counts, theorists have sought to define a successor model, giving rise to a discipline of Medical Ontology, the study of the conceptual foundations of medical science (Foss, 2002).

The Biopsychosocial model

The late psychiatrist George Engel (1977) first advocated a new paradigm for Western medicine, a systems approach and a new ideal known as the Biopsychosocial model. This model offered an integrative alternative to the biomedical model, when science was gaining momentum in its evolution from an exclusively analytic, reductionist, and specialised field to become more contextual and cross-disciplinary. A holistic stance was advocated, with greater emphasis on social, psychological and contextual factors to treating and managing illness. Philosophically, the Biopsychosocial approach, also referred to as a systems approach, represents how disease and suffering are affected by multiple factors, from societal and behavioural to molecular. Practically, it is a way of understanding the individual's subjective experience and behaviour as essential components in promoting health outcomes. This new epistemology thus embraced Systems Theory, and endorses what is now encompassed by theories of CAS (Borrell-Carrió, et al., 2004; Engel, 1977, 1980; Flores, et al., 2013; Foss, 2002; Schwartz & Wiggins, 1986).

The three key characteristics of the Biopsychosocial model defining it as a new medical paradigm are outlined as:

1. A view that incorporates the patient's subjective experience in parallel with biomedical data.
2. A more comprehensive and naturalistic model of assessment of the causes of illness than linear, reductionist, positivist models.

3. A patient-clinician relationship in which the patient is an active participant in the clinical process as opposed to a passive subject of investigation.

Engel's ideas introduced a fundamental ideological shift, characterised by a systemic approach that humanises medicine and empowers patients (Borrell-Carrió, et al., 2004).

Moreover, in contemporary discussions around systemic approaches to behavioural health, the term 'Biopsychosocial' is sometimes interchanged with 'Biopsychocultural', which distinguishes between two types of behavioral variables that may influence health outcomes. Social variables are shared with animals (for example, overcrowded living conditions or lack of social support), while cultural variables are unique to humans (for example, regarding breast cancer: cultural influences and beliefs about cancer, the breast, and women's illnesses in general) (Foss, 2002).[2]

Engel's Biospychosocial model is therefore fundamentally based on a systems approach, seeking to understand how human systems behave – internally as individuals, as well as interdependently with each other and the environments in which they exist. (Hayles, 1999; Jones, 2015; Schwartz, 1982; Schwartz, & Wiggins, 1986).

Infomedicine

Advancing the Biopsychosocial approach, the concept of Infomedicine emerged in the late 1980s (Rothenberg & Foss, 1987) to describe a further successor paradigm for biomedicine, also founded in Complexity/Systems understanding (specifically Cybernetic). The concept of Infomedicine was welcomed by Engel as he acknowledged the structural boundaries inherent in the term 'bio-psycho-social', which had proven problematic in its adoption by the medical community, being misunderstood and misused, through an ironically separate interpretation (Foss, 2002). The concept further places the patient/consumer at the centre of health or

[2] In the pursuit to better understand and address the complexities of psychological, social and cultural impact on health and behaviour, the biopsychosocial approach has influenced the emergence of interdisciplinary approaches within and between the behavioural, social and biomedical sciences (Schwartz, 1982). Examples include social anthropology, political psychology, ecological psychology to psychophysiology, behavioral neurology, neurophilosophy and sociobiology. It is not uncommon to see three different disciplines merge to form fields such as social psychophysiology, psychoneuroendocrinology, and psychoneuroimmunology, interpersonal neurobiology and mindfulness-based cognitive behavioural therapy (MCBT). Further examples of a similar hybridations are behavioural economics and neuroeconomics (Datta & Mullainathan, 2014; Schull & Zaloom, 2011) The digital revolution is leading to further transdisciplinary collaboration as new possibilities for behavioural interventions that act on a profoundly embedded and systemic level (Swan, 2012a).

disease management, as "an information processing system with multilevel programs, processing multilevel messages, whose interaction determines the health and wellbeing of the system" (Rothenberg & Foss, 1987, p. 201).

The Infomedical proposition is fundamentally different from the biomedical approach in that "the body as a [mindless] machine" is replaced by the Cybernetic view of the body as a self-organising system requiring a constant flow of information (feedback) to maintain its state of organisation in a changing environment. Although it is recognised to exhibit some machine-like features (and that medical work at this level can still add to progress), it is emphasised that it exhibits properties possessed by no machine. The human body is an adaptive, information-processing system that interacts with its physical, social and cultural environments, both mindfully and autonomically. Information flows between all levels of the organism. At each level, the organism's receptors process and interpret information by 'translating' it into its own 'program' or language, producing applicable change. Information transfer is as significant an agent of change as energy transfer, but the causal process in the two cases is different. Energy transfer generates change by action on a passive object while information transfer generates change by activating a process that is already a potential of the system. In the human subject, this latency has a life, and mind, of its own. The resulting change, the physiological response, reflects this life and mind. Therefore, in an infomedical context, health and disease are not simply biological, but psychobiological phenomena (Foss, 2002; Varela, Thompson & Rosch, 1992).

The Wisdom Traditions

Far preceding Western acknowledgement of a systems (Biopsychosocial) approach, evidence of the application of holistic methods, also described as Vitalist, is found in the ancient Asian (2600 B.C.) and Greek (500 B.C.) traditions. The Vitalist approaches developed as healing arts that emphasise dynamic mind-body integration (reflexivity and mindfulness) and active participation of the patient, with the unbalanced individual as object and restoration of balance (homeostasis) recovery or enhancement of their health (the goal). This is in stark contrast with the biomedical approach, which has illness as object and the fight against it the goal (Luz & De Camargo, 1997).

A growing body of research deals with synergies that exist between Complexity Sciences and Buddhist psychology (Brown & Ryan, 2003; Flanagan, 2011; Foss, 2002; Garland, 2007; Hayles, 1999; Langer, 2014; Varela, et al., 1992; Williams & Kabat-Zinn, 2011).

Cybernetic models offer insight into the processes of cognition and its effect on behaviour, resolving discord between the mechanistic, rational assumptions of early cognitive science and real life, providing insight into irrational/maladaptive behaviour in systems, and offering more effective approaches to addressing these (Brown & Ryan, 2003; Varela, et al., 1992). Mindfulness, a core aspect of which is attentional sensitivity to psychological, physical and environmental cues, is emphasised as key to the communication and control processes that underlie the regulation of behaviour in systems. Biofeedback and behavioural science research has extensively underpinned the influence of attention in addressing maladaptive behaviour patterns, reducing unhealthy physical conditions, symptoms of disease and in rectifying disregulation that occurs when signals are ignored or suppressed. Attention re-establishes communication between elements of a system (for example, mind and body, or thought and behaviour, connection between individuals). Mindfulness involves perceiving stimuli simply 'as they are', which creates optimal internal cognitive conditions for effective biofeedback and re-integration to occur. Mindfulness practices are thus widely advocated for psychological and behavioural self-regulation to promote wellbeing (Boekaerts, Pintrich & Zeidner, 2005; Brown & Ryan, 2003; Brown, Ryan & Creswell, 2007; Foss, 1994; Garland, 2007; Maturana, 1981; Schwartz, 1982; Varela, et al., 1992; Williams & Kabat-Zinn, 2011).

In the language of Autopoietic Theory, mindfulness practice and subjective self-observation are referred to as 'embodied' and open-ended reflection that relates directly to experience. It is advocated as a prerequisite for adaptive behaviour – to promote reflexivity, self-organisation, emergence and enactment in resilient systems. 'Enactment' is defined as mindful physical (embodied) action, integrating the observer with the physical world – as we enact, we are naturally 'embodied' in it. 'Embodied' refers to sensory-motor experiences of a physical body – biofeedback – as a prerequisite for cognition. The concept of enactment thus integrates the Cartesian divide of mind-body dualism. Knowledge to self-organise and self-replicate – heal and maintain wellbeing – is thus the result of creative cognition produced by interconnections between our physical bodies, language, society and the world (Maturana & Varela, 1980; Varela, et al., 1992).

The field of Interpersonal Neurobiology asserts that mindful observation and action assist the complex, non-linear system of the mind in achieving states of self-organisation by balancing two opposing processes (rigidity and chaos) to create 'integration', a state of functioning that is flexible, adaptive, coherent, energised and stable. The effects of 'integration' in the individual is described as a physiologically (neurologically) integrated brain, a coherent mind (rational/intelligible), an empathetic relationship (with others as well as with the self) – a symbiosis that supports adaptive, healthy behaviour (Siegel, 2006; 2007).

Ancient approaches to health and wellbeing are resurfacing in the Western thought world, creating a convergence of synergistic epistemologies of post-enlightenment science and systemic approaches to health. The synergies that exist are unified by fundamental principles of Complexity Science (Borrell-Carrió, et al., 2004; Foss, 1994; Luz & De Camargo, 2016; Varela, et al., 1992; Williams, & Kabat-Zinn, 2011).

2.3.5 Realising Systems Medicine

Context

Since the early 2000s, the early pioneers of Systems Medicine have advocated the shift in health care from reactive disease care to a pre-clinical emphasis that is predictive, preventative, personalised and participatory. The field of Systems Medicine profoundly exemplifies Complexity Sciences, offering a fundamentally new and far more powerful paradigm than traditional reductionist approaches. It is already showing promising results in improving the sustainability of health care, through a holistic but personalised, quantified, cross-disciplinary approach (Janetos, 2009; Flores, et al., 2013; Hood & Auffray, 2013; Swan, 2012a). This approach is also referred to as Precision Medicine, Stratified Medicine, Personalized Medicine, and 4P Medicine (predictive, preventative, personalised and participatory). It is closely related to Evidence-based Medicine (Cullis, 2015; Flores, et al., 2013; Swan, 2012a).

Three megatrends in the field of information and communication technologies (ICT) are accelerating its realisation:

- Systems Biology and Systems Medicine, providing increasingly sophisticated computational devices and methods for deciphering biological complexity of health and disease.
- New digital means for collecting, integrating, storing, analysing and communicating data and information, including conventional medical histories, clinical tests and the results of the tools of systems medicine.
- Patient/consumer access to information and subsequent interest in managing their own health.

(Flores, et al., 2013; Swan, 2012a)

These megatrends are enabling the holistic and quantified systems approaches to understanding the complexity of health, disease and wellbeing.

Systems Biology

The forerunner of Systems Medicine, Systems Biology is an interdisciplinary field, a hybridisation between biology and engineering, which has led to a significant number of important recent innovations and discoveries in complex systems, enabled by technological and computational advances. Pioneered in the laboratory of Leroy Hood since the late 1970s, the now formalised Institute for Systems Biology (ISB) has produced some of molecular biology's core instruments. These include the invention of devices for measuring, synthesising, detecting, and sequencing physiology on various molecular levels, specifically the individual genome (DNA) and proteome (amino acid structures) and, most notably, the invention of the DNA Sequencer which has enabled the sequencing of the complete human genome, with the conclusion of the Human Genome Project in 2003. Collectively, the implications for the practice of molecular biology and health care have been profound, in terms of measuring individual biological markers, in turn increasing personalisation, accuracy and effectiveness of care (Hood, 2013). [3]

[3] Hood attributes his remarkable success in innovation to a systems-driven, integrated and cross-disciplinary approach to addressing the challenge of deciphering biological – and human – complexity. Collaboration between disciplines, for example, biological, physical, ecological and computational scientists, mathematicians, engineers and system designers, is a requisite in the quest for understanding, predicting, altering and controlling behaviours of biological systems (Anthony C Janetos, 2009; Hood, 2013; Hood & Flores, 2012; McHattie et al., 2014).

In practical terms, this translates into greater availability of powerful, detailed molecular-level information about individuals and the diseases or disorders to which they may be susceptible, or already have, in digital format, accessible through the Internet. For example, genome sequencing enables detection genetic predispositions to common diseases, ranging from heart disease to diabetes, certain cancers, depression and dementia, as well as information about whether a drug is likely to be effective or produce harmful side-effects for a specific individual. Personal genome sequencing is becoming increasingly accessible, making data available to be stored as part of an individual's medical record. The same applies for further levels of molecular analysis. Proteome measurement can provide accurate insight into disease already present in a system or detect trends towards its development, enabling early intervention. Further analyses can reveal the effects of specific treatment or changes in environment, lifestyle and behaviour. As such, accurate, quantified information, detailing increasingly holistic personal health scenarios, is being produced by the instruments of Systems Biology (Cullis, 2015; Hood, 2013; Smarr, 2012; Weston & Hood, 2004).

Foundations of Systems Medicine

Systems Medicine is the application of Systems Biology in health care. Two central premises exist. The first is centred on the expanding range of health technologies (from DNA sequencers to personal health devices and PI systems, to social networks) to produce vast global data sets that track multiple dimensions of dynamic internal and external network interactions. Massive amounts of data obtained from diverse networks are integrated to generate a comprehensive and inclusive base for better understanding human health, disease and wellbeing. For example, with this information it is possible to gain insight into how the combination of individual genetic composition and specific environmental and behavioural factors affects health and disease. Such insight holds powerful potential for research and development of innovative approaches to prevention, diagnostics and treatment (Cullis, 2015; Flores, et al., 2013; Swan, 2012a).

The second is the conviction that within 5-10 years, every patient will have a personal data cloud made up of billions of data points that holistically and dynamically reflect the individual's state of health and factors that have an impact on it, enabling prediction of future wellness and disease. Medical treatment will thus be increasingly informed by computational analyses that distil multi-dimensional data (biological as well as environmental) to

comprehensible information and actionable recommendations, designed with the objective of minimising disease while enhancing wellbeing of individual patients (Cullis, 2015; Hood & Price, 2014; Swan, 2012a).

Thus, the expanding capacity to measure a full spectrum of health-related aspects at multiple levels – from the most basic determinants of our physiological identities, i.e. the molecules that make up cells, to the cells that make up organs and tissues, to the functioning of these organs and tissues organs – is driving Systems Medicine. Along with the ability to measure and track behavioural and environmental factors that affect our physiological state on various levels, this provides even more complete data sets that facilitate early detection, effective treatment and the ability to intervene to correct undesired trends, before disease manifests (Cullis, 2015; Hood & Price, 2014; Swan, 2012a, 2013).

P4 Medicine

Systems Medicine is also referred to as P4 Medicine – health care that is predictive, preventative, personalised and participatory (Flores, et al., 2013; Hood, 2013; Hood & Auffray, 2013; Hood, et al., 2012; Hood, Heath, Phelps & Lin, 2004; Hood & Flores, 2012; Weston & Hood, 2004).

In brief, 'predictive' refers to how individual data clouds that incorporate sophisticated physiological data will enable forecasting of future wellness and disease. 'Personalised' acknowledges that each individual is genetically and environmentally unique and must serve as their own control over time (n = 1) to detect accurate individual trends and transitions from healthy to disease states. 'Preventative' focuses on how data can be used to optimise individual wellness and actions that can be taken to stop or delay predicted disease (Flores, et al., 2013; Sobradillo, Pozo & Agusti, 2011).

'Participatory' refers to an inclusive approach in which a full range of health care stakeholders (payers and providers) – including, consumers (the well), patients (the sick) and researchers, physicians, policy makers, administrators, pharmaceutical companies, insurance companies, and medical diagnostic laboratories – are involved in a complex collaboration to transform health care to make it more proactive than reactive, and consequently more

effective and sustainable (Flores, et al., 2013; Hood & Auffray, 2013; Sobradillo, et al., 2011).

'Participatory' further refers to the new forms of proactive engagement by patients and healthy individuals to better understand and manage health and wellbeing using ICTs, for example, the Internet (such as 'Dr Google'), patient-driven social networks (for instance. PatientsLikeMe) and, most relevant for this study, personal informatics systems (Quantified Self applications and devices). These personal informatics systems provide behavioural and environmental data that create far more complete data sets that comprehensively reflect the complexity of an individual's health in ways that have not been possible in the past (Flores, et al., 2013; Hood & Auffray, 2013; Hood & Flores, 2012; Swan, 2012a).

Of the '4 Ps', the participatory component is described as the most challenging to implement, as by nature it requires an inclusive approach that considers complex dynamics among an intricate network of stakeholders (Flores, et al., 2013; Hood & Auffray, 2013). Important requirements are outlined as:

- Education about the concepts of P4 medicine across all stakeholder segments.
- Effective personal data aggregation into integrated systems that enable mining for actionable knowledge (while accounting for issues of user experience, security and privacy).
- Creation, adoption and continued use of personal informatics systems by patients and consumers, which is essential for reaching a critical mass for large-scale success of P4 medicine.

(Flores, et al., 2013; Hood & Auffray, 2013).

The emergence of a new health care paradigm is further evident in five mutually supportive and growing trends in health care:

1. Reliance on data averages from restricted clinical test groups is being replaced by mathematically advanced analyses of 'big data' generated by billions of data points from individuals in relevant population cohorts.
2. Diseases are being identified and treated with far greater precision and cost-effectiveness, based on molecular and cellular origins rather than types of symptoms.

3. New, accelerated innovation cycles are emerging as discovery science converges with medicine and wellness care.
4. Biomedical health care is moving beyond disease care in clinical settings to include preventative care through proactive preservation and enhancement of wellness by consumers in their daily lives, in their homes and workplaces.
5. A new wellness industry is beginning to emerge that will become a major source of economic growth in the 21st century.

(Flores, et al., 2013; Hood, 2013; Hood & Auffray, 2013; Hood, et al., 2012)

Parallels with early systems approaches

The current revolution in health care is in stark alignment with ideals of earlier proposed models and theories, as outlined in 2.3.3. Computational advances are facilitating the actualisation of many of these early ideals, through the increasingly sophisticated ability to capture physiological, psychological (behavioural) and environmental data as well as extensive participatory features.

Systems Medicine provides powerful support to Engel's ideals and the key aspects of the Biopsychosocial model of the late 1970s, which advocated the following:

- A more comprehensive model of assessment of the causes of illness than linear, reductionist, positivist models.
- A patient-clinician relationship in which the patient is an active participant in the clinical process as opposed to a passive subject of investigation.
- A view that incorporates the patient's subjective experience.

(Borrell-Carrió et al., 2004; Engel, 1977).

Systems Medicine further provides the tools to profoundly realise ideals of the Infomedical model, as first proposed by Foss and Rothenberg in the late 1980s, which placed the patient and his/her multi-dimensional data at the centre of health or disease management (Rothenberg & Foss, 1987). Information is essentially becoming the fundamental currency of the emerging health paradigm (Janetos, 2009). Between the starting point of the individual's genome sequence and the end-point of the expression of that individual's health, exists an intricate web of exceptionally complex interactive networks. The new generation of Systems

Biology and Quantified Self instruments are providing fundamental advances in the flow of information, through the ability to collect data from key nodes in these complex networks, offering unprecedented access to biological, behavioural and environmental information and the ability to observe the multidimensional systems that underlie health.

Explained through Buddhist-influenced Cybernetic theories of Cognition, the ability to observe and measure an expanding range of physiological, behavioural and environmental parameters, accurately, simply as they are, offers unprecedented biofeedback capacity that encourages mindful awareness that in turn promotes psychological and behavioural self-regulation to promote wellbeing (Garland, 2007).

2.3.6 Summary

Throughout this sub-chapter, two approaches to health care have been delineated. The first is, specifically, the traditional Modern Biomedical approach, which is reductionist, dualist and clinical, with disease as the central focus This is contrasted with the second: the emerging, Post-Modern, Systems Medicine approach, which is inclusive, non-dualist and naturalist, with the individual as the central focal point in health and is viewed as a complex system of wellness and prevention, as opposed to an isolated condition or pathology, incorporating psychological (including behavioural) and social (including cultural) aspects in parallel with biomedical factors.

The Systems Medicine approach, propelled by the digital revolution, next-generation data practices and increased participation by patients and consumers in managing their personal health and lifestyle through a broad range of personal informatics systems, provides a framework to integrate the strengths of biomedical sciences with social sciences. This inclusive, holistic approach is driving the health care of the future, which is preventative, predictive, personalised and participatory. The following section will discuss the current application of PI systems to manage their health and optimise wellbeing in greater depth.

2.4 Personal Informatics Systems in Practice

2.4.1 Overview

Information is the fundamental currency of the emerging health paradigm (Janetos, 2009). An important segment of this growing corpus of information is self-tracked, 'crowdsourced' data, collected by networked individuals as they proactively participate in self-regulating of their own health through personal informatics (PI) systems that record behavioural patterns, including physical activity, nutrition, sleep and stress, creating data points of rich contextual data to complement biomedical data (Flores, et al., 2013; Hood, 2013; Lupton, 2014, 2015; Nafus & Sherman, 2014; Schüll, 2015; Swan, 2009).

The broad spectrum of PI systems forms the basis for contemporary quantified self (QS) practices. The phenomenon, including the entire scope of tools, applications and technical approaches related to this school of thought, has taken different labels and can be found in literature as personal informatics (Li, Dey & Forlizzi, 2010; Munson, 2012b), personal analytics (Choe, Lee, Lee, Pratt & Kientz, 2014), self-tracking, data for life or life-logging (Lupton, 2014; Schüll, 2015), Living by Numbers (Oh & Lee, 2015). Popular PI brands include Fitbit, Jawbone, Withings, Garmin, Polar, Strava, MyFitnessPal, Clue Apple Health and Samsung's SHealth. These brands represent extensive ranges of wearable devices and mobile applications.

PI systems are becoming increasingly pervasive as they are being adopted, not only by end-users (patients and consumers) to improve personal health, but also across industries and in broader health and social contexts, to influence health and lifestyle behaviour of key segments. This, in turn, is driving the upsurge of a new wellness industry, a significant new source of economic growth (Hood & Flores, 2012; Swan, 2012b).

Globally, the adoption of PI systems has soared over the past five years. In 2011, 14 million PI system devices were sold worldwide. This figure is predicted to rise to 170 million in 2016 (Swan, 2012b). Soreon Research estimates the global market to have been US $2 billion in 2015 and that it will rise to $41 billion by 2020. Another research organisation, IDTechEx, predicts that the wearable technology market will reach $70 billion by 2024 with health care as the dominant sector (Chang, 2015). With the widespread uptake of PI systems, science-based health care is moving beyond clinical settings to include proactive preservation and

enhancement of wellness by consumers in their everyday lives – incorporating behavioural and environmental factors. This data continually being generated by individuals is becoming increasingly invested with symbolic, cultural and commercial value and status, evident in activated consumer networks such as the Quantified Self movement (Lupton, 2014), or more relevantly in South Africa, in Discovery Vitality.

Foucault's (2004) writings on the practices and technologies of the self in neoliberalism are pertinent to understanding the participatory approaches in Systems Medicine through PI systems, as a particular mode of regulating the self. The neoliberal self is positioned as a responsible citizen, willing and able to take care of her or his wellbeing, without the need for political coercion to behave productively and in the interests of the self and the state, i.e. citizens voluntarily engage in behaviour that meets both personal and state objectives. Organisational (governmental) power is exercised through the regulation, monitoring, and surveillance of citizens' bodies and behaviour and encouragement of citizens to engage in these practices on their own behalf, to improve quality of life through active risk management and regulation of health. PI data collected as part of self-tracking and the patterns and associations that can be identified as a result play a powerful role in this form of neoliberal self- and population management. Systems medicine and recent forms of neoliberalism are thus closely intertwined and linked with PI system practices as these participatory approaches expand networks and spaces in which self-monitoring and self-management can be exercised. New ways of gathering detailed real-time data about individuals, a window into people's lives, are presented, thus becoming increasingly integral in a political environment and part of government policy and corporate endeavours to improve various outcomes, for instance to maximise worker productivity and reduce health care expenditure, including insurance claims (Foss, 2002; Foucault, 2004; Lupton, 2013b, 2014; Nafus & Sherman, 2014; Wolf, 2010).

2.4.2 The Quantified Self Phenomenon

The Quantified Self (QS) movement has grown into a global phenomenon since being founded in 2007 by the editors of *Wired* magazine, Gary Wolf and Kevin Kelly, with the purpose of creating collaboration between users and manufacturers involved in the early development of the concept of "self-knowledge through numbers", i.e. personal informatics (PI). In 2008, the online platform, quantifiedself.com, was launched. In 2011, the movement held the first QS conference. Quantified Self Labs has since grown into a company that

produces international meetings, conferences, community forums, web content and services. It has expanded into a global community with regular Quantified Self member groups' 'meet-ups' being held in over 120 cities worldwide. The Quantified Self website lists over 500 self-tracking tools, including health, fitness, weight, sleep, diet, mood, feeling and geolocation tracking apps, services and devices that are able to record social interactions, emails, networks and social media status updates and comments. Other tools listed further allow users to monitor their television watching, computer use, driving habits, financial expenses, time use, beneficial habits, work productivity, meditation practices, environmental conditions, progress of learning or the achievement of personal goals (Wolf & Kelly, 2009).

QS is, however, more encompassing than simply the organised, branded movement and refers to the general progression in human history bringing order, understanding, manipulation, and control to the natural world, including the human body by means of measurement, science and technology (Swan, 2013). Extending the premise that "the unexamined life is not worth living" (as attributed to Socrates by Plato), QS advocates systematic personal behavioural and biological monitoring, to create a comprehensive personal data landscape for the purpose of self-experimentation, self-regulation and self-reflection, oriented to drive change or improvement. Through various PI systems, the individual has the ability to understand his or her own patterns and baseline measures, and obtain early warnings as to when there is variance and what to do about this. Self-tracking, self-monitoring, self-awareness self-regulation, experimenting, and action-taking are critical components in the QS and preventative medicine movements (Lupton, 2016; Marcengo & Rapp, 2013; Swan, 2009, 2012a; Wolf, 2010).

In 2010, Wolf spoke at a TED conference, raising what it means to think of one's own data from a subjective viewpoint as a mirror (as opposed to a window from an objective/institutional viewpoint), probing what kinds of observation, reflection, learning, personal insights, modified behaviour and ways of being might emerge with such a stance (Wolf, 2010). This raises the Cybernetic viewpoint, "to act effectively, it is necessary that information concerning the results of one's actions be furnished as part of the information on which one must continue to act" (Wiener, 1954, p. 35). Wolf (2010) further described big data from an institutional viewpoint as a "window" into peoples' lives. The following section will explore how the new wellness industry and health care institutions are integrating the PI phenomenon.

2.4.3 A New Wellness Industry

The emerging trends in consumer-activated health networks (for example, QS and Discovery Vitality) and subsequent data generation, tracking and consumption are supporting the rise of a new, specialised wellness industry, a promising source of economic growth globally. (Flores, et al., 2013; Hood & Auffray, 2013; Lupton, 2016; Swan, 2012a). Lifestyle data (collected by PI systems) is thus increasingly being commoditised, finding application across industries. For example, health insurance companies are including PI systems as part of their programmes, mining data to gain insight into members' behaviour to calculate – and regulate – risk profiles. Similarly, corporates are using these systems as part of employee wellness programmes to improve productivity. PI systems are starting to infiltrate public health care systems as state health care organisations deploy Apps and 'wearables' among patients to provide more scalable and efficient care. The collection and analysis of PI data are further being promoted and implemented by institutions and in broader social contexts, including education, marketing and commerce, the military, citizen science, urban planning and management. People are being 'encouraged', 'nudged', 'obliged' or 'coerced' into using digital devices for monitoring aspects of their lives to produce personal data which can then be used to gain insight and influence behaviour (Chang, 2015; Christie & Yach, 2015; Etkin, 2014; Lupton, 2014, 2016; Swan, 2013).

New business models are emerging as new incentives are gradually starting to shift health care to a system with greater mutual accountability through compensation for improved health outcomes rather than the sale of products and services. Ultimately, the wellness industry is moving towards being able to capitalise on its ability to improve health outcomes, while supporting Systems Medicine by providing important facets of behavioural and lifestyle data (Flores, et al., 2013; Hood & Auffray, 2013; Hood & Flores, 2012).

Combining PI systems with behavioural economics strategies and programmes that 'nudge' individuals to engage in specific actions has been shown to be effective in promoting continued use and improved health outcomes (Christie & Yach, 2015; Patel, et al., 2011; Strum, et al., 2013). Recent studies have concluded that incentive-based health promotion programs that leverage PI systems are associated with lower probabilities of hospital admission and lower hospital costs in the following two years (Christie & Yach, 2015).

However, the surfacing of unintended negative consequences of behaviour modification interventions is being documented by a growing body of research (Etkin, 2014; Fishbach & Choi, 2012; Lupton, 2014; Stibe & Cugelman, 2016; Van Dijk, et al., 2015).

The increasing culturally embedded nature of PI systems and the powerful potential of this complex phenomenon to encourage healthy, adaptive behaviour, demands considered processes to inform development and design of systems that optimally support individuals in managing their wellbeing, while avoiding unintended consequences, ultimately to promote healthy networked cultures. "We need to develop user-friendly software solutions for crowdsourcing [of health data] enabling an efficient highly interactive patient[user]–healthcare interface" (Hood, et al., 2012, p. 8).

2.4.4 Positive Technology

Positive technology (PT) is defined as the scientific and applied approach for improving the quality of our personal experience with the goal of increasing wellbeing, promoting strengths, resilience, engagement and meaning in individuals, organisations, and society by means of technology (Botella, et al., 2012). This new field combines the objectives of Positive Psychology with enhancements of information and communication technologies (ICTs) by focusing on three key variables that serve to promote adaptive behaviours and positive functioning, namely: emotional quality (hedonic or enjoyment level), engagement/actualisation (eudaimonic or wellness level), and connectedness (social and interpersonal level) (Botella, et al., 2012; Graffigna, et al., 2013; Riva, Baños, Botella, Wiederhold & Gaggioli, 2012; Wiederhold & Riva, 2012). To be considered 'positive', technologies should be designed to improve the quality of life, promote wellness and generate resources and strengths in individuals. Positive technologies should further provide intrinsically satisfying experiences that engage users in a process of continuous development centred on needs for competence, connection, autonomy and optimism (Wiederhold & Riva, 2012).

In parallel with the development of the emerging health paradigm and 4P Medicine (Flores et al., 2013; Swan, 2012a), positive technology is developing to support the broad context of preventative medicine, from a holistic, biopsychosocial perspective as well as to complement mental health care (Wiederhold & Riva, 2012). The positive technology approach thus has an

important function, to be diffused throughout the innovative technologies that support this paradigm – specifically for the purpose of this study, PI systems designed to promote sustained behaviour change for lasting wellbeing.

2.4.5 Persuasive vs. Mindful Technology

According to Munson (2012a), an important consideration in the design of PI systems is the balance between how persuasive vs. reflective a system will be, i.e. will the system nudge users toward goals, or will it help users set goals and support them to follow through on them? Will it reveal data in a neutral way, allowing people to gain their own insights but without any overt push to change or maintain their behaviour in any way? Either type (persuasive or reflective) can motivate behaviour change, though the former explicitly promotes certain behaviours through its design (Munson, 2012a).

Persuasive technology is broadly defined as technology designed to change attitudes or behaviours of the users through persuasion. It is a design philosophy that was developed to improve business outcomes, and productivity and to reduce cognitive loads in a commercial context (Chen, 2011; Chen, Hekler, Hu, Li & Zhao, 2011). A narrower definition is systems that push users to behave in particular ways, without those people choosing behaviour change as an explicit goal (Munson, 2012a). Commercial PI systems are predominantly persuasive, incorporating features such as goals, and rewards or incentives for achievement thereof, and challenges to engage the wearer in specific activities and behaviours (Fritz, Huang, Murphy & Zimmermann, 2014), i.e. behaviour economic strategies. Persuasion-based systems further apply behaviour economic strategies by focussing on simplifying behaviour and reducing cognitive load required to self-track. This approach has proven successful in encouraging health behaviour change in some areas, yielding positive results particularly in motivating physical activity (Gao, 2012). The focus is predominantly to optimise output, performance and productivity rather than self-understanding, which can limit users' potential to engage in a way that helps them to find new ways to improve and change (Moore, Kleek, Karger & Schraefel, 2010). When PI systems take a persuasive (also described as assistive) approach they assume a paternalistic role, which restricts the user from making conscious choices, reducing users' autonomy and limiting personal empowerment (García, 2014). By streamlining and automating actions such as monitoring, the opportunity for users to cognitively engage in behaviour change is compromised (Gao, 2012). Behaviour change is

more likely when greater context and correlations are provided to create content and opportunity for reflection and personal insight (Li, Forlizzi & Dey, 2010). Thus overtly persuasive system design is receiving increasing criticism as researchers are finding that not enough consideration is given to users' mental processes and that too much control is being assumed by systems (Gao, 2012).

Conversely, mindful technologies, also referred to as reflective technologies, encourage users to engage with their mental and emotional state to stimulate adaptive behaviour. As behaviour change is a complicated process, it requires people to engage deeply and proactively in the full spectrum of the process of change for an extended period. Reflexivity in learning, which includes practising and maintaining a new behaviour, is advocated to deepen self-knowledge the environment and others (Gao, 2012). An emphasis on technology-mediated reflection is absent in many PI systems – persuasive technologies that aim to incite behaviour change (Chen, 2011; Chen, et al., 2011; Gao, 2012). Through mindful design, PI systems have the potential to shift the users' focus from an external to an internal locus control. The latter enables conscious decision-making and commitment in the individual as an essential basis for attitude change and for lasting behaviour change[4] (Niedderer, 2013).

2.4.6 Persuasive Strategies: Behavioural economics

The Nudge

In the pursuit of understanding human behaviour better, the discipline of behavioural economics (BE) has brought together psychologists, economists, social scientists, neuropsychiatrists, neuro-economists and others since the 1970s. Its synthesis of multidisciplinary insights has enabled a deeper understanding of complex human behaviour than any one of these disciplines is able to offer on its own. BE offers insight into what motivates people's decisions and actions, offering explanations for unexpected, irrational reactions and behavioural anomalies. Based on these insights, BE further provides strategies to manage such behaviours. BE thus provides policy makers and system designers with new approaches and strategies for addressing complex behavioural dynamics that affect

[4] Cybernetic Parallels: PI systems can be categorised as positive and mindful technologies when they are engineered to facilitate Cybernetic processes of feedback, reflexivity and communication to promote synthesis of data to wisdom, i.e. accurate and relevant data structured and organised to support cognition to drive mindful and adaptive behaviour – self-organisation, resilience and wellbeing. Persuasive technologies, although valuable and effective in certain aspects, are presented as less effective in supporting cognitive processes required for profound change, and should thus be applied with care and caution.

sustainability challenges faced by the global society. Furthermore, BE is increasingly being applied in the health care domain to a myriad of behavioural interventions, thus supporting preventative and participatory care (Ariely, 2009; Blumenthal-Barby & Burroughs, 2012; Datta & Mullainathan, 2014; Dolan, et al., 2012; Kahneman, 2011; Kahneman & Tversky, 1979; Thaler & Sunstein, 2008).

BE theories support behavioural change when choice architects (for example PI system designers) apply these strategies in the design of an environment that implicitly steers the user towards certain choices and actions instead of others. Incentives and nudges can substitute explicit instructions and restrictions, for example presenting particular default options in some functionalities improves the likelihood of a particular action from the user. Setting a goal and/or offering a reward provide effective motivation for desired behaviour, often far more powerful than a simple instruction. Such systems are described as "libertarian paternalist" as they are designed to gently persuade the user towards desired, beneficial action in a non-coercive manner as implied by traditional paternalism (Thaler & Sunstein, 2008). BE thus offers insight into how to design intelligent systems that optimise relevant key touch-points with a choice architecture that encourages a desired choice or action by tapping into subtle psychological drivers and by anticipating otherwise unforeseen behavioural anomalies. These principles are incorporated in the design of PI systems to subtly, often subconsciously, persuade desired behaviour to promote health outcomes.

Behavioural economics principles

To enable identification of BE strategies in the design of PI systems, a review has been conducted of principles as discussed in the literature (Amir & Ariely, 2008; Ariely, 2009; Blumenthal-Barby & Burroughs, 2012; Dolan, et al., 2010, 2012; Halpern, et al., 2004). The acronym MINDSPACE is presented to encapsulate the primary set of BE principles that appear throughout the literature (Dolan, et al., 2010, 2012). These principles are outlined briefly in the table below. A detailed description is provided as Appendix A.

Table 1: MINDSPACE – BE in an easy format (Cabinet Office and Institute for Government, 2010)

Messenger	We are heavily influenced by who communicates information.
Incentives	Our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses.
Norms	We are strongly influenced by what others do.
Defaults	We 'go with the flow' of pre-set options.
Salience	Our attention is drawn to what is novel and seems relevant to us.
Priming	Our acts are often influenced by subconscious cues.
Affect	Our emotional associations can powerfully shape our actions.
Commitment	We seek to be consistent with our public promises, and reciprocate acts.
Ego	We act in ways that make us feel better about ourselves.

It is clear that using a combination of tools and principles from BE, system designers, policy makers, employers, insurance companies, researchers, and health care providers can have a profound effect on influencing behaviour by tapping into the less obvious and finer nuances of human nature and the automatic responses of the unconscious mind. For example, salient messaging directed at people's ego states can create behavioural anchors, which have the power to intervene in existing behaviour patterns and to create a foundation for specific altered action and thus catalyse behaviour change.

However, the long-term effectiveness of relying on persuasive techniques that tap into System 1 thinking to instil new behaviour and sustained wellbeing in real world settings is questioned and, as such, the depth of the learning experience and the long-term effectiveness of BE strategies require further research (Dolan, et al., 2012; Stibe & Cugelman, 2016).

2 Brains: Reactive and mindful

BE delineates two systems of thinking that determine decision-making and behaviour, i.e. an automatic, quicker type of cognition (System 1) and a more purposeful, reflective, mindful type of cognition, (System 2) (Kahneman, 2011). This 'dual-brain hypothesis' represents an adaptation on the theme of split-selfhood that is prevalent throughout Western thought – a tension between competing tendencies, described as automatic vs. controlled, effortful vs. effortless, deliberative vs. impulsive, conscious vs. unconscious, planner vs. doer, and/or abstract vs. visceral (Dow Schull & Zaloom, 2011). Thaler & Sunstein (2008) name the older

limbic, or ‘Automatic’, system ‘Homer Simpson’ and contrast this ‘savage’ with the hyper-rational ‘Dr Spock’ of the ‘Reflective’ system.

During ego depletion, caused by stress, exhaustion, hunger and feelings of being overwhelmed, the responsibility of choice is seized from the mindful System 2 by the automatic System 1. This causes the idiosyncratic irregularities of human decision-making, which thus reflect the rivalry between an impulsive present-biased midbrain system, that is activated by instant gratification, and the sensible, responsive, future-focussed prefrontal cortex that is activated by all rewards, regardless of time frame (Baumeister, Sparks, Stillman & Vohs, 2008). Liabilities, biases and heuristic responses are therefore inherent in System 1 thinking and have a pervasive influence on our thoughts and behaviour. Activating the power of more engaged System 2 responses assists in avoiding contra-productive mental reactions. Higher functions of controlling thoughts and behaviours, such as self-control and cognitive effort, are ‘mental work’ and functions of System 2 that require conscious engagement and more energy than System 1. During times of stress or ego-depletion, we are more likely to default to impulsive, irrational, often incoherent System 1 thinking, which is often self-defeating. Thus, to avoid errors that can originate from System 1 one must acknowledge the signs being in a ‘cognitive minefield’, take a step back and draw on assistance from System 2 (Kahneman, 2011).

Persuasive design and BE tactics essentially exploit System 1 processes, as they tap into subconscious predispositions, to nudge users to make cerain actions without having to effortfully engage System 2 in decision-making processes. This is particularly pertenent in situations where mental resources may be overwhelmed or depleted and cognitive capacity to think through challenges and enable the right decisions is compromised (Datta & Mullainathan, 2014). When applied in systems which promote healthy behaviour, this is easy to justify. However, due to the persuasive nature of these tactics the depth of the experience of learning new behaviour and the sustained practice thereof, is questioned, with referrence to the discussion of Persuasive vs. Mindful technologies.

Furthermore, conscious engagement of System 2 thinking inherently promises a ‘fitter’ brain that makes better choices for more constructive behaviour. The mindfulness literature suggests that self-reflective and self-management practices as advocated in various contexts have a valuable function in this regard (Borrell-Carrió, et al., 2004; Dubberly, et al., 2010;

Epstein, Siegel, & Silberman, 2008; Kabat-Zinn, 2013; Langer, 1992, 2000; Munson, 2012a; Siegel, 2010; Swan, 2009, 2012a).

2.4.7 Negative Technology: Unintended Consequences of QS

PI systems have become analogous with digital compasses whose continuous tracking and analytic capacities can help consumers to navigate the field of everyday choice-making and better control their behaviour – e.g. steps, calories, sleep and heart rate – toward wellness. This clearly categorises these technologies in the 'Positive' domain. A QS company slogan suggested by Lupton states: "Your body is the ultimate interface problem. Sometimes, it just doesn't give you the feedback you need … We create the tight feedback loops your body is missing to keep you healthy" (Lupton, 2013a, p. 397). But how *healthy* is this kind of reliance on technology? By offering a way to simultaneously embrace and outsource the task of lifestyle management, do these products simultaneously exemplify and short-circuit cultural ideals for individual responsibility and self-regulation (Schüll, 2015)? Since the early enthusiasm about QS, a set of contrary views have emerged that reflect these ideas. There is evidence of a growing cynicism concerning the value of the data gained from quantifying the self, among academics, healthcare professionals, as well as contributors of online forums and other publications (Etkin, 2014; Lupton, 2015; Stibe & Cugelman, 2016; Van Berkel, Luo, Ferreira, Goncalves & Kostakos, 2015; Van Dijk, et al., 2015).

As contended by Foucault, however: "There has been no major medical advance that has not paid the price in various negative consequences" (Foucault, 2004, p. 11). This emphasises the importance of considered approaches to development and design of PI systems that respect the systemic complexity of these interventions to minimise unintended effects. A review of concerns raised in academic literature follows.

Reductionist assessment

Rudimentary, superficial and limited PI system measurement can misrepresent actual reality (Lupton, 2015; Van Dijk, et al., 2015). The broader context in which data is generated is vital to understanding what that data means to users in the context of their lives. Numbers without context can lead to misconceptions, inaccurate assessments, recommendations and communication that can cause adverse effects, ranging from counter-productive behaviour

changes, anxiety to injury, compromising wellbeing. Context is thus required to frame data in a more insightful way, to 'humanise numbers' and to avoid maladaptive reactions (Gao, 2012; Lupton, 2015; Stibe & Cugelman, 2016; Van Dijk, et al., 2015).

Excessive self-focus

Obsessive engagement with PI can lead to extreme self-focus, which can be damaging and undermine wellbeing (Chance, 2013; Van Dijk, et al., 2015). Two kinds of attentiveness to one's inner thoughts and feelings have been identified, the first being a ruminative style that involves judgment or assessment; the second is described as a philosophically oriented self-reflection. The ruminative style is understood to be maladaptive with characteristics of addiction and obsession, while the reflective style is presumed more adaptive (Trapnell & Campbell, 1999). It has been found that abstract thinking (rumination) about outcomes, meanings and implications tends to be maladaptive, while concrete reflection about processes and plans makes for better problem-solving (Watkins, 2008).

Over-trust of data

Preconceptions about the capabilities and accuracy of technology can lead to the belief that data provided by PI systems offers a more dependable and objective view than users' own subjective experience. The vast availability of quantitative data that provides exact (though not always accurate) numbers provided by automated and semi-automated tracking far outweighs the amounts of quantitative, individual, subjective data that are more complex to track. PI data presented to reflect a simple relationship with underlying behaviour and physiological processes can thus be deceptive. Furthermore, extreme reliance on PI system feedback can lead users to disregard their own experience, which can lead to data-dependency – feelings of detachment and of being under-informed when data is not available (Van Dijk, et al., 2015).

Healthism and responsibility

Self-tracking promotes the idea that if something can be measured, it can be improved. This can unintentionally turn into an obligation, pressuring users to keep changing and improving even if they are unable to or if the changes are unrealistic. This takes the ideology of

'healthism' – health as a responsibility of which each individual must take charge – to unbalanced levels. Similarly, users of PI may experience pressure to 'perform' beyond what is healthy, toward maladaptive obsession and neurosis. Furthermore, not all individuals may be willing or able to use self-tracking technology, due to various factors such as age affecting digital 'fluency' – or cost (Lupton, 2013b, 2015; Van Dijk, et al., 2015).

Extrinsic vs. intrinsic motivation

Research shows that quantifying and measurement produces similar outcomes to external rewards and incentives, framed as numeric incentives. While these tactics can improve and increase outcomes and activities, they can simultaneously undermine intrinsic motivation. It has been found that by drawing attention to output, quantifying emphasises a measurable outcome of engaging in enjoyable activities, which can in turn diminish intrinsic drivers. It is suggested that extrinsic incentives can cause activities to be experienced as work, making them less enjoyable, constraining spontaneous and continued engagement (Etkin, 2014; Fishbach & Choi, 2012; Stibe & Cugelman, 2016).

Overemphasising

Persuasive tactics can motivate people to take action for one strongly emphasised benefit, while omitting or hiding possible harmful factors (Chance, 2013; Stibe & Cugelman, 2016). For example, a system may encourage physical activity while recovering from injury or in an environment where it may not be safe, thereby compromising their welfare (Chance, 2013).

Self-licensing

When someone does something good in one area, they sometimes feel as if they have a licence to misbehave in other areas (Stibe & Cugelman, 2016). For example, someone reaching a daily step goal may feel entitled to overindulge in an unhealthy, high-calorie dinner.

The above examples reveal the effects of persuasive strategies in PI system design, emphasising complexities, illustrating how various dynamics can lead to unintended, adverse effects and maladaptive, 'mindless' behaviours.

The following section will explore existing conceptions that inform design of mindful technologies and PI systems adopt reflective strategies to promote adaptive behaviour for wellbeing.

2.4.8 Reflective Strategies: Design for Mindful Awareness

Mindful/reflective technology is an emerging field, a counter movement to persuasive technology and its overtly 'gamified' approaches to system and UX design, a response to negative perceptions and outcomes thereof, as explored in the previous section (Gao, 2012; Munson, 2012b; Munson & Consolvo, 2012).

From data to mindful behaviour

Li, Dey & Forlizzi (2011) explored the potential of PI systems and resulting data to facilitate self-reflection and in turn promote self-awareness, adaptive behaviour and better health-related decisions by users. Through comprehensive assessment of user interaction with PI systems, the Stage-based Model of Personal Informatics Systems was developed to provide a practical basis for development and design of mindful technologies, along with four key properties that characterise these systems.

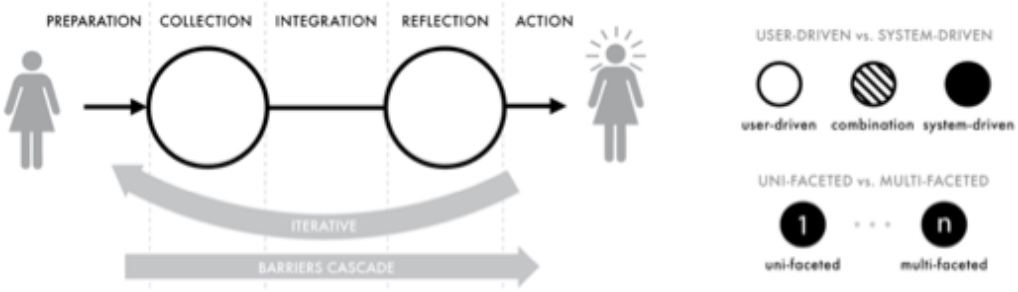


Figure 2: The Stage-based Model of Personal Informatics Systems (Li, Dey, et al., 2010).

Five stages of the self-tracking process are identified as follows:

1. Preparation
2. Data collection
3. Data integration

4. Reflection
5. Action

The four key properties of PI systems are identified as follows:

1. Barriers exist at each stage which cascade to subsequent stages.
2. Stages are iterative.
3. Systems can be user- or system-driven (manual or automatic).
4. Systems can be uni- or multifaceted.

A similar model is presented by Van Berkel, Luo, Ferreira, Goncalves & Kostakos (2015) with the QS Data Cycle as outlined in Figure 3.

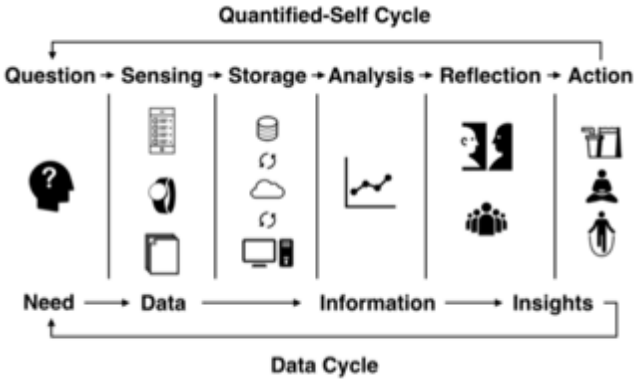


Figure 3: Different stages of QS and how a user's need for data leads to insights through collection and conversion from data into information (Van Berkel et al., 2015)

The QS Data Cycle is outlined as follows:

1. Question: A need is investigated.
2. Sensing: Through the collection of data, for example, smartphone.
3. Storage: Data is then stored in a certain format, e.g. on a computer or in the cloud.
4. Analysis: Data becomes information through data analysis, by, for example, statistical or visualisation tool.
5. Reflection: Users reflect on the information alone or with others – creating knowledge.
6. Action: Users may gain insight and act accordingly, for example, diet or exercise.

It is stipulated that the cycle may start over at the analysis or reflection stage if the information is poor or not useful, and may reiterate several times for more data.

Data, Information, Knowledge, Wisdom (DIKW)

Powerful parallels can be drawn between the processes and sequences of these models (Li, Dey, et al., 2010; Van Berkel, et al., 2015), and the Data, Information, Knowledge, Wisdom (DIKW) model, developed by various information scientists and systems theorists over time, chiefly attributed to Ackoff's (1989) contribution to organisational change and knowledge theory with the classification of the human mind into five hierarchical categories:

1. Data: Facts or symbols.
2. Information: Data processed to be meaningful.
3. Knowledge: Application or organisation of data and information.
4. Intelligence or Understanding: Appreciation of 'why'.
5. Wisdom: Evaluated understanding or applied knowledge, leading to action.

Figure 4: A simplified, analogous depiction of DKW (Data, Knowledge Information) (The Futurist, 1982)

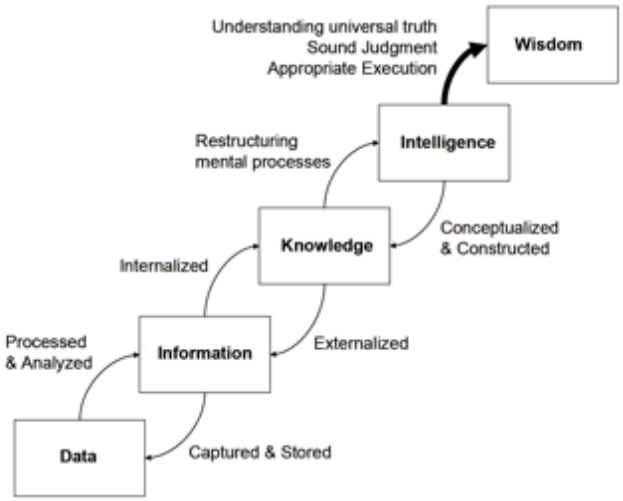


Figure 5: Revised DIKIW (Data, Information, Knowledge, Intelligence Wisdom) cycle (Liew, 2013)

As demonstrated in the diagrams above, unstructured information of reality is recorded to become data, which can then be structured to form information, revealing connections and patterns leading to knowledge and understanding. Wisdom is attained when deep understanding of acquired knowledge is intelligently synthesised and applied. New information is blended with prior experience to lead to adaptive action. The first four categories deal with the past. Knowledge is defined as the collection of data and information of what is or has been known. Understanding or cognition synthesises knowledge with previous experience, vision and planning (design) of the future, leading to wisdom – enactment – the ability to create value (Bellinger, Castro & Mills, 2004; Kapeleris, 2012; Liew, 2013).

Contrarily, the antithesis of Ackoff's model implies a hierarchy of stupidity, folly, errors, misinformation, and data – a domain of 'non-knowledge', based on data gaps and misinformation, offering a reasoning for many of history's systemic catastrophes (Bernstein, 2009).

This emphasises the importance of an accurate and holistic approach in system design that considers integrity of processes at each stage to avoid cascading flaws. The following guidelines are suggested:

1. An increase in devices used by individuals necessitates that systems allow for extensive and complex data-sharing capabilities between these devices.
2. In order to form a holistic and contextually relevant understanding of a person's self, analysis should include psychological data, which can be obtained through human input.
3. In order to be of value to people's lives, PI systems should be adaptive to support changing questions and goals that individuals ask and set over time as they progress and their needs change.

(Lupton, 2015; Van Berkel, et al., 2015; Van Dijk, et al., 2015).

The researcher further argues the importance of:

1. Considered and meaningful tracking parameters.
2. Data accuracy.
3. Considered and meaningful language used for prompts, instructions and contextual feedback.

2.4.9 The Observing Self

Data visualisation and mindful behaviour

Visualising technologies in medicine, such as x-rays, computer tomography, ultrasound and magnetic resonance imaging to monitor, record, observe and interpret the interior of the body, have formed a crucial part of medical screening and diagnostics for decades, becoming increasingly important in health care as they produce significant shifts in how the body and health states are conceptualised, articulated and portrayed. Where patients and physicians previously relied on haptic sensations for feedback on health states, medical visualisation has transformed these feedback and monitoring practices by "revealing the *truth* of the body" (Lupton, 2013a, p. 398). The use of PI systems to record and reflect physiological and behavioural parameters is a logical extension of visualising technologies, as they aim to modify user behaviour by means of portrayal of self-tracked data which enable analysis, assessment, correlation, pattern recognition and ultimately, adaptive action (Duval, 2011; García, 2014; Lupton, 2013a; Marcengo & Rapp, 2013; McCurdy, 2015; Swan, 2009, 2012a).

PI practices and resulting data are often described as a mirror into the self, reflecting a continuous inner landscape and personal behavioural patterning, thus offering unprecedented opportunities for self-observation, reflection, internal communication, cognitive processes, learning and personal insights – feedback that drives mindful awareness and adaptive behaviour aimed at optimising or 'reorganising' the self, i.e. health and wellbeing (Marcengo & Rapp, 2013; Wolf, 2010).

Such approaches are increasingly incorporated in new post-rationalist approaches as models of behavioural psychology, based on the premise that this kind of attention is key to the cybernetic communication and control processes that underlie the regulation of behaviour. Examples of these approaches are Cognitive Behavioral Therapy (CBT) (Marcengo & Rapp, 2013) and mindfulness-based approaches (Brown, et al., 2007).

In cybernetic terms, personal data visualisation offers a powerful capacity for the individual (as a system) to observe itself, which creates feedback loops that promote mindful, adaptive behaviour toward self-organisation and resilience, i.e. health and wellbeing.

Second-order cybernetics (Maturana & Varela, 1987) further emphasises the influence of the observer in determining the effect of environmental feedback or stimulus. External feedback does not cause a response but stimulates the individual to shift into one of its own inherent response patterns. Thus, the response is determined by the individual's own cognitive or self-organisational process. Seen in this light, a mindful stance supports adaptive responses to feedback events "creating freedom to construct one's own coherent reality out of the encounter" (Garland, 2007, p. 24; Maturana & Francisco, 1987).

Furthermore, drawing on Complexity Theory, Interpersonal Neurobiological views describe how the intricate, non-linear system of the mind achieves states of self-organisation through mindful awareness and visualisation techniques that balance two opposing processes to create integration, bringing with it a state of FACES – Flexible, Adaptive, Coherent, Energised and Stable (Siegel, 2001). Integration is described as a rational flow that exists between extremities of chaos and rigidity. Characteristics of integration are further defined as an empathetic relationship (with others and the self), a coherent (rational/intelligible) mind, and an integrated brain (neurological integration through prefrontal cortex/System 2

engagement). This integrated flow is the goal of mindful awareness in the optimisation of wellbeing (Siegel, 2006, 2007).

Being mindful about mindfulness

Many definitions and conceptions of mindfulness exist in recent literature. The following section explores these views and present viewponts adopted in current clinical application, to create context for the purpose of this study.

In the Buddhist tradition, mindfulness is an integral part of the path towards understanding the causes and ending of suffering; a means to free oneself from patterns that cause perpetuate suffering and pain. In this context, mindfulness creates the potential to develop insight, new perspectives, and so to facilitate personal transformation. That said, mindfulness, being about awareness and attention, is not specifically Buddhist. Mindfulness is universal – we are all mindful (Crane, Winder, Hargus, Amarasinghe & Barnhofer, 2012; Flanagan, 2011; Kabat-Zinn, 2013; Siegel, 2009a).

As such, Western adoption of mindfulness is widely removed from its spiritual origins and is focused predominantly on the inherent therapeutic benefits, i.e. happiness and wellness, although common threads emphasise Buddhist principles of *samatha* (concentration, calmness, and stability), *jhana* (absorption), and *vipassana* (insight), each of which is associated with specific types of contemplative practice and related techniques (Kirmayer, 2015). It is therefore important to emphasise that mindfulness is not reliant on specific practices, as often assumed or implied (Kabat-Zinn, 2013), but is essentially a psychological construct that is not rooted in any particular mechanism or set of exercises, such as Buddhist seated meditation, as often assumed. In this sense, meditation is just one of many functions in the construct of mindfulness. This is analogous to the role an antidepressant drug has in relation to depression – a mechanism that can influence a psychological state; just as antidepressants are not the only way to alleviate depression, meditation is not the only way to foster a state of mindfulness (Pagnini & Philips, 2015). Mindfulness practice is thus viewed as the cultivation of dispositional traits that eventually will impact all aspects of one's everyday life (Kabat-Zinn, 2013; Langer, 1992; Pagnini & Philips, 2015; Siegel, 2009a; Vacca & Hoadley, 2016).

In its current clinical applications, mindfulness, or mindful self-awareness, typically refers to present-centred, non-judgmental or non-evaluative attention (Kirmayer, 2015), a way of being that, through supportive activities, leads to cognitive reframing, characterised by a conscious disposition, described as being attentive, recognising the world as constantly changing, noticing subtle changes in the current situation and in the inner self (Langer, 2000). It is seen as a transient state in which the mind and body (mental experiences and sensory information) are cognitively monitored, with characteristics of curiosity – defined as present moment awareness with an investigative interest – and decentring – defined as shifting from identifying personally with one's thoughts and feelings, to seeing them as passing mental events rather than ingrained reflections of reality (Vacca & Hoadley, 2016).

Evidence for the benefits of mindfulness is directly related to facilitating improved biofeedback and responses as awareness facilitates attention to prompts arising from basic needs, making one more likely to adaptively regulate behaviour. It further promotes fulfilment of the basic psychological needs for autonomy (self-endorsed or freely chosen activity), competence and relatedness (Brown & Ryan, 2003; Brown, et al., 2007).

Mindfulness, self-reflective and self-management practices as advocated in various contexts, have a valuable function in engaging and building resilience of the reflective System 2, to support better self-control, planned action, and rational choices, creating a more robust foundation for sustained behaviour change (than reliance on System 1 interventions). Greater self-awareness, being aware of how we engage our internal thinking systems, being attentive to our current or present state of being, and how these aspects influence our judgments and decisions, promises insight and greater ability to act in ways that are conducive to success and wellbeing (Brown & Ryan, 2003).

2.4.10 Summary

This section created a context for framing PI systems as an interface between users and their health states. Effective interface design strategies can promote self-regulatory behaviour change through mindful self-awareness and adaptive responses to feedback in users. PI systems can therefore incorporate a balance of persuasive and reflective strategies to cultivate a necessary balance of mindful attitudes which include elements of curiosity, present-centred

awareness, attentiveness and recognition of patterns and correlations in a constantly changing internal and external environment.

2.5 Chapter Summary

The literature presented started with an introduction of the field of Inclusive Innovation and introduced complexity theory as an approach to understanding and addressing systemic challenges, behavioural phenomena and adaptive (mindful) dynamics. This was followed by an exploration of historical approaches in health care leading to the emerging health care paradigm, Systems Medicine, after which the supporting role of PI systems and the Quantified Self movement were dealt with. Concepts around positive, persuasive and mindful technologies were discussed, followed by complexities and concerns that have emerged, specifically drawing attention to behavioural economics principles. This was followed by a discussion of the concept of the observing self and the role of mindful awareness in promoting adaptive behaviour.

Summary of the core argument as supported by the literature

The prevailing Western biomedical paradigm, although effective in delivering disease care, is not positioned to effectively address complex societal challenges or solve the sustainability problems facing health care and delivery. Systems Medicine and its P4 approach advocate a shift to a participatory, person-centric model with a pre-clinical focus, drawing on the potential health and lifestyle PI systems to assist in realising this approach. This viewpoint paper argues that PI systems form a powerful new interface between individuals and health management, that offers unprecedented capacity for users to observe and better understand their own health states and the complex factors that impact their wellbeing. These interfaces therefore act as feedback mechanisms that, when effectively designed, can generate greater self-awareness, which leads to mindful, adaptive behaviour toward better health.

Strategies applied in design play an important role in ensuring that feedback is delivered in a style likely to promote meaningful, lasting change. Two categories of strategies are presented which represent two opposing styles: persuasive and mindful. Both approaches are effective in encouraging change; however, each presents concerns and barriers.

To gain deeper understanding of persuasive design strategies, behavioural economics principles are explored. Application of Complexity Theory (cybernetic) principles, specifically concerning how feedback mechanisms promote mindful and adaptive behaviour, are referenced throughout to gain insight into mindful design strategies.

It is the viewpoint of this paper that, when applied in a balanced and considered way, these strategies have the potential to complement each other, i.e. persuasive strategies can be applied to nudge users toward more mindful and reflective engagement.

A phenomenographic research approach, which is fundamentally person-centred, is adopted to better understand the lived experience of users' engagement with PI system and their inherent design strategies. This offers a new approach to gaining insight into user behaviours, motivations and opinions, thus including their voices in the design process, allowing system designers to critically address real issues, avoid unintended consequences and offer durable solutions to behavioural health challenges. Such an approach may further contribute to addressing the important complexities and challenges in the changing health care landscape and in so doing develop **innovative approaches to PI systems design to support future care**.

3 RESEARCH APPROACH AND METHODOLOGY

3.1 Introduction

Every inquiry is a seeking. Every seeking gets guided beforehand by what is sought (Heidegger, 1962, p.24).

The current study seeks to understand the qualitatively different ways in which users experience personal informatics (PI) systems; specifically how these systems promote behaviour change and improved wellbeing. It further explores the application and experience of persuasive and mindful design strategies in PI system UX design in practice. The current study makes use of a phenomenographic research methodology, which seeks to provide a human-centred lens to the qualitatively different ways in which people experience various aspects of their world. The methodology is focused on exploring the connections formed between research subjects and objects.

3.2 Issues of Ontology and Epistemology

This study is naturalistic in nature – naturalistic enquiry being contrasted with the positivist paradigm in social research (Lincoln & Guba, 1985). This seminal work represents an ontological turn in constructs of naturalistic enquiry (Norris & Walker, 2007) having been produced at a time when the positivist approach to research was dominant in the social sciences, when interpretive studies were seen as 'undisciplined … "sloppy" research, engaging in "merely subjective" observations' (Lincoln & Guba, 1985, p. 289). The naturalistic enquiry starts from the assumption that phenomena should be studied in their natural setting and considers realities as multiple, constructed and holistic; the knower (user) and the known (phenomenon) are seen as inseparable and interactive. The naturalistic researcher thus assumes a non-dualistic stance, the goal of enquiry being to produce working hypotheses and case-based knowledge (Lincoln & Guba, 1985). Naturalistic behaviourism is inclusive of the observer in the research context, recognising that research often emerges from the lived and felt experiences of the research (Denzin, 1971).

An interpretivist worldview, also described as a social constructivist worldview (Creswell 2013), has been adopted as the researcher is concerned with understanding the aspects of the world in which respondents live. Through the process, the researcher has inductively developed multiple and varied subjective views of respondents' experiences of PI systems to formulate a theory or pattern of meaning. This is in line with the position of constructivism as summarised by Lincoln and Guba (2000). While the primary focus of the current study is on participants' views, it is recognised that the researcher's interpretation is influenced by her own experiences and background, hence the description of "interpretive" research (Creswell, 2013). Furthermore, multiple methods of data collection have been used to best answer the research question and develop an outcome space along with actions, situations and consequences of the enquiry, which is consistent with an interpretive framework (Creswell, 2013).

3.3 Phenomenography

The current study makes use of a phenomenographic research methodology, which seeks to provide a lens to the qualitatively different ways in which people experience various aspects of their world. Phenomenography is described as a research specialisation with the aim of mapping "the qualitatively different ways in which people experience, conceptualise, perceive, and understand various aspects of, and various phenomena in, the world around them" (Marton, 1986, p. 31). It is supported by the concept that people collectively experience and understand phenomena in various qualitatively distinct but interrelated ways (Booth, 1997; Marton, 1986). Thus, phenomenography is concerned with describing things as they appear to, and are experienced by, people (Marton & Pang, 1999).

Phenomenography was predominantly established by Swedish researchers in the 1970s in the field of education (Marton & Svensson, 1979; Säljö, 1979). It emerged from research led by Ference Marton to investigate variation in student learning outcomes (Yates, Partridge, & Bruce, 2012). Phenomenography has historically been concerned with exploring questions related to how people learn and see knowledge within a particular context (Svensson, 1997). Phenomenography has since been extended to studying the result of any learning experience across various new domains. Examples of contemporary application are discussed further in section 4.4.

Phenomenographic analysis aims at a very specific, thematic level of description, corresponding to a level of experience believed to be critical as far as the outcomes of facing phenomena in certain ways are concerned. As such, data is analysed to reveal the most distinctive sets of characteristics that describe the most pertinent interaction with a phenomenon, i.e. structurally significant differences that clarify how people define, experience, interpret and interact with specific elements of their world. These categorisations of descriptions of conceptions or experiences are the primary outcomes of phenomenographic research and are captured in an outcomes space, which maps the various ways in which a phenomenon is experienced (Barnard, McCosker & Gerber, 1999; Booth, 1997; Bruce, 1999; Marton, 1986; Yates, et al., 2012). Marton (1986) contends that by mapping the concealed world of human conception, phenomenography assists in revealing conditions that can transform one way of thinking to a qualitatively "better" perception of reality.

3.4 Justification

Marton (1986) emphasises that phenomenography shares four of the primary characteristics of phenomenology, i.e. that it is relational, experiential, contextual, and qualitative. Both approaches share similarities in relation to the rules of interviewing and the overall object of research – to reveal human experience and awareness; however phenomenography is less interested in immediate, individual experience than it is in reflective, collective meaning and experience. It is a second-order research approach, which is experiential, aiming to describe the world as it is understood, rather than a first-order (phenomenological) perspective in which the world is described as it is. Phenomenology focuses on the essence of experience, while phenomenographers characterise the variations of experience, considering variation itself as the essence of experience.

Barnard, McCosker and Gerber (1999) identify phenomenography as an emerging and valuable approach to qualitative health care research, reiterating the value of the characteristics that distinguish it from phenomenology, particularly when people's understanding of their experience is the goal. They highlight that phenomenography has been categorised into three lines of inquiry, the first being continued concentration on general aspects of learning. The second concerns the learning of concepts in domains, such as economics, mathematics, or health care, while the third is characterised as 'pure' phenomenographic interest and is concerned with describing the way in which people

conceive of various aspects of their world. The researcher argues that phenomenography is an appropriate and innovative approach to the research question and believes that a structured, categorised outcome holds more definitive, nuanced value for the evolution of the PI phenomenon and its potential to enhance user wellbeing than does a phenomenological account.

3.5 Issues of Trustworthiness

In the context of phenomenography as a naturalistic enquiry with an interpretivist research approach, Lincoln and Guba (1985) argue that it is not appropriate to defend the positivist standards of validity, reliability and objectivity in measuring the value of interpretive research, but rather that the concept of the trustworthiness, also described as the 'authenticity' of the investigation, should be argued. Here the notions of 'credibility' and 'dependability' are presented as equivalent to the traditional research notions of validity and reliability to judge the value of interpretive studies (Norris & Walker, 2007).

Credibility is a more appropriate term to use for the positivistic construct, 'validity'. Credibility is not only left to those interrogating the research findings, but rather incorporated in the design of the study that begins with the definition of the object of research and follows through each aspect of the study to its conclusion. Furthermore, it includes an implicit relationship with the community outside the study through an interaction around the research findings as they are created (Collier-Reed, 2006).

Bowden and Walsh (2000) state that to ensure validity (credibility), phenomenographers need to be clear about the purpose of their studies and strategies to achieve their objectives and that all research should refer back to those intentions (Francis, 1993). Dependability is a more appropriate term to use for the positivistic construct 'reliability'. Ensuring the dependability of a study is important as it allows for consistency of data interpretation and thus consistency in the research findings of an investigation. To ensure dependability, care must be taken during the interview conversation, during transcription of the data and, most importantly, during constitution of the categories of description (Collier-Reed, 2006).

Inquiries of reliability of phenomenographic data are further comprehensively addressed by Sandbergh (1997), who suggests that reliability as interpretive awareness is more appropriate

than reliability as replicability. Interpretive awareness is thus an important construct to ensure dependability. Furthermore, Marton and Booth (1997) have argued that the category of description is 'a reasonable characterisation of a possible way of experiencing a phenomenon in the world given the data at hand' (p.136). The researcher has explicitly and comprehensively substantiated categorical interpretations, with the relevant theoretical frameworks as reference points.

3.6 Chapter Summary

This chapter has demonstrated how the phenomenographic method will be applied to gain insight into the qualitatively different ways in which people experience a PI system design and how it changes behaviour and impacts mindfulness and wellbeing. The researcher has argued for a naturalistic enquiry with an interpretivist approach, drawing attention to the lenses through which data is viewed to support trustworthiness, credibility and dependability.

4 METHOD

4.1 Introduction

The methodological foundations of phenomenography indicate that the data collected represents individuals' experience of a phenomenon as described by that person. This chapter describes the method developed to facilitate the collection of such data.

The chapter begins by outlining the data collection strategy used in the investigation describing how context was created by means of the literature review and landscape analysis, and how an online survey was used to identify appropriate respondents to form part of a purposive sample group for interviewing to represent a varied accounts of experience of the phenomena under investigation.

A detailed discussion follows of how the data was collected through a series of surveys and semi-structured interviews. The chapter concludes with a section discussing how the trustworthiness of the results was established.

4.2 Data Collection Methods

Data collection methods included:

1. Academic literature
2. Landscape analysis (Appendix B)
3. Online survey
4. Semi-structured interviews (users)

As outlined above, data collection included four sources of evidence: academic literature, a landscape analysis, an online survey and semi-structured interviews. The literature review and landscape analysis served as the foundation upon which the research was built. This process of undertaking a literature review, conducting interviews with industry experts and participating in a research internship, an immersion in an environment of PI system designers

and administrators, provided a solid foundation for gaining deep understanding of the context in practice. It enabled the researcher to identify knowledge gaps, needs and pain points and to formulate a specific research problem that filled a gap in current research and aimed to answer questions currently being posed by academics, system designers and health care professionals.

The industry interview process also contributed to identifying a suitable population of PI system users, including athletes, patients, Vitality members and a more general public to recruit as online survey respondents. It served as a filtering process to identify a suitable sample for interviews. The final sample was selected based on suitability, ease of access and willingness to assist.

Although all four methods of data collection informed the research, the phenomenographic outcome space was informed only by the data collected from the online user survey and user interviews. The literature, industry expert interviews and landscape analysis informed the lens through which the data was viewed and analysed and thus facilitated and contextualised interpretation.

4.2.1 Academic Literature

A wide range of reference material was sourced from books, electronic journals, articles, publications, practitioner literature and academic databases. Initial article searches were conducted using phrases of the terms developed during a concept analysis. From the articles collected, abstracts were analysed and compared in order to select articles that offered the highest degree of relevance, legitimacy and validity. The researcher drew on a wide array of resources to obtain an overview of thought leadership and best practice as applied in the relatively new fields of personal informatics, persuasive and mindful design, specifically, behavioural economics and mindfulness landscapes. It must be noted that the academic literature available in 2016 is of significantly greater quantity than that available at the beginning of the study. A far greater community of researchers are having papers published that specifically link concepts of PI systems, persuasive and mindful (also referred to as reflective) technologies. This has served as validation and affirmation of the relevance of the work to the researcher.

4.2.2 Landscape Analysis (See Appendix B)

To gain a deeper practical understanding of the field, a landscape analysis was conducted, which included a two-month research internship with Discovery Vitality[5], semi-structured interviews with various industry experts, personal experimentation with various PI systems and an analysis of popular PI systems.

4.2.3 Online Survey

To assist in purposive sampling, an online survey was distributed to individuals to assess the use of personal tracking methods and their views. Respondents were sourced through industry experts, including dieticians, distributers of fitness devices, fitness coaches, professional coaches, the athletic community, Vitality members and staff as well as the researcher's personal network. Fifty-one survey responses were received and from this a group of ten individuals was selected to be interviewed in greater depth, based on their profile.

The survey was designed to:

- Profile the user (age, gender, income group, and living area);
- Establish PI tracking methods (including specific apps and devices, duration of use, reasons for use);
- Assess the users' attitude towards the chosen method, based on the Stage-Based Model of PI Systems (Li, Dey, et al., 2010);
- Gain insights into effective persuasive and reflective UX design elements; and
- Assess the effect of use on behaviour and wellbeing, based on concepts of wellbeing and mindful awareness (Baer, et al., 2008; Kabat-Zinn, 2003; Langer, 2000; Siegel, 2009a).

Snapshot of the sample group profile:

[5] Discovery Vitality Strategic Programmes and Wellness departments, working on Active Rewards, Vitality Dashboard and mental wellbeing product design

- Gender: 17 females, 34 males.
- Age: Ranging from 26 – 72.
- Income: The average annual income reported was R1,5 M+; however, the majority of respondents indicated that they 'prefer not to share'.
- Location: South Africa, Cape Town and Johannesburg, primarily upper income areas.

The vast majority of respondents indicated that they had health insurance or a hospital plan, with only three uninsured and relying on public health care; 30 of the respondents were insured with Discovery Vitality.

The majority of respondents indicated that they were using PI systems to manage physical activity, diet, performance, lifestyle and general health; 75% of respondents indicated that they use smartphone applications to track their goals, and 48% of respondents indicated that they use a device or 'wearable' of some kind.

Strava was by far the most used PI system, followed by Polar, MyFitnessPal, Apple Health, Garmin, Fitbit, RunKeeper and Vitality (Active Rewards). Although there was significant representation of other PI system brands, the brands listed all had ten or more users.

Over 70% of users indicated that they were self-motivated to improve their wellbeing. In terms of mechanisms that they found useful, users indicated that they responded best to progress bars, charts, numbers and counts, graphs, previous performance data, push notifications and non-virtual incentives. Push notifications were also indicated as the biggest irritation and hindrance.

In assessing how users experience the effect of PI interaction on wellbeing and mindful awareness, the researcher found the responses to be significantly polarised. The vast majority answered 'agree' or 'strongly agree' to questions relating to improved wellbeing and positive experience, and conversely 'strongly disagree' or 'disagree' to questions gauging undermining effects on wellbeing and negative user experiences. This indicates an overwhelmingly positive effect of PI tracking activity on wellbeing, in general. However, it might also indicate that the ways in which many of the multiple choice questions were posed nudged respondents to answer in a certain way. This might be due to the language used,

referring to terms from the literature, such as *mindful*, *integration*, *chaos*, *rigidity*, *reflection* and *awareness,* which do not necessarily form part of a colloquial vocabulary but are rather influenced by the language of the discipline. Furthermore, as this survey was an introduction to the face-to face interviews, the wording and content may have primed users to answer interview questions with particular preconceptions in mind, influencing their stance and language during the interview.

Examples of this would be:

23. My tracking activity causes a sense of disconnection/disintegration/chaos. Please indicate the extent of your agreement with this statement.

24. My tracking activity supports reflection, which helps me to better understand myself, my behaviour, my progress or lack thereof. Please indicate the extent of your agreement with this statement

Answering the survey and being exposed to the concepts raised throughout questioning may also have affected their views on tracking and tracking activity in the period between answering the survey and being interviewed.

4.2.4 Semi-Structured Interviews

Through purposive sampling, 12 users were selected based on their varied profiles and responses to the online survey. As the outcome of a phenomenographic analysis is the variation in the ways a phenomenon is experienced, it is essential to ensure that the participants selected are appropriate to enable this variation to be as extensive as possible. The most appropriate way of achieving this is to select a number of 'critical cases' to ensure as much variation as possible (Collier-Reed, 2006). Representability of a population is therefore not crucial, but rather ensures maximum diversity of conceptions and attitudes in participants with respect to the phenomenon. Thus, selection of participants takes place through the careful consideration of the researcher rather than by using any kind of quantitative criteria. The result of this 'critical case' selection is that the cultural and gender profile of a population will not necessarily be statistically represented. Collier-Reed (2006) further emphasises that this is not at odds with the phenomenographic approach where the

focus is on describing the key aspects of the variation of the experience of a phenomenon rather than focusing on the richness of individual experiences.

A set of in-depth, face-to-face semi-structured interviews lasting between 30 and 80 minutes were conducted using an open-ended question guide to establish perceptions, attitudes, approaches and experiences of PI system design. These allowed the researcher to gain deeper insight into the effect of interaction on participants' behaviour and wellbeing. All interviews were recorded and transcribed verbatim for analysis. As the interviews progressed, the researcher refined their style of interviewing to allow for greater focus to avoid digression as experienced in the earlier interviews. Later interviews proved to be more focused and provided more relevant and valuable phenomenographic data.

The introductory question to all interviews asked respondents to define what wellbeing meant to them personally, creating a context for the approximately five questions, which were structured around conceptions of PI tracking experience, drawing on the Stage-Based Model of PI Systems (Li, Dey, et al., 2010) to inform the primary research question. Further probing around behaviour change, effects on self-awareness and wellbeing was influenced by concepts of wellbeing and mindful awareness to inform the secondary research question (Baer et al., 2008; Kabat-Zinn, 2003; Langer, 2000; Siegel, 2009a).

Seven of the 12 respondents were Discovery Vitality members, of whom only four had activated the Vitality Active Rewards programme and of whom three had taken the Apple Watch benefit.

The selection of user interview respondents is outlined below:

Table 2: Interview Respondents

	Profession	**Gender**	**Age**	**Race**	**City/Town**	**Tracking Method**	**Vitality**
1	Professional Triathlete (Olympian)	Female	28	White	Stellenbosch / Boulder, Colorado (Bermudan)	Garmin, Training Peaks	No
2	Estate Manager	Female	35	White	Somerset West	Run Keeper, Jawbone, Journal	Yes
3	Change Manager	Female	28	White	Johannesburg	Apple Watch Vitality / Active Rewards	Yes

4	Personal Trainer	Female	29	White	Cape Town	Polar, MyFitnessPal	No
5	Marketing Manager / Ex-Professional Triathlete	Male	30	White	Stellenbosch / Boulder, Colorado	Strava, Garmin, Training Peaks	Yes
6	Sales Manager / Ex- Professional Cyclist	Male	39	White	Cape Town	Garmin, Strava, Training Peaks	Yes
7	CEO	Male	45	White	Cape Town	Garmin, Strava,	Yes
8	CEO	Male	43	Indian	Johannesburg	Garmin, Strava, Apple Watch Vitality / Active Rewards	Yes
9	Model/Entrepreneur / RAA Alumna	Male	29	Black	Cape Town (Zimbabwean)	Journal, Apple Health, Various Free Apps	No
10	Clinician/Medical Doctor	Male	58	Indian	Johannesburg	Apple Watch, Vitality Active / Rewards	Yes
11	UX Specialist	Male	40	White	Johannesburg	Jawbone, Vitality / Active Rewards	Yes
12	Retiree	Male	72	White	Cape Town	Apple Watch, Vitality / Active Rewards	Yes

4.3 Data Analysis

The aim of a phenomenographic analysis is to develop an outcome space that represents a set of related, qualitatively different, hierarchical categories of description. To achieve this, the traditional Swedish method is preferred. This suggests dealing with interview transcripts and survey data by extracting a relevant selection of fragments that refer to the experience of the phenomenon. All these excerpts that relate to the experience of the phenomenon are then placed in what is referred to as a 'pool of meaning' (Marton, 1994). Fragments of the ways of experiencing the phenomenon – 'meaning units of experience' – have thus been combined to represent the variation in ways in which this phenomenon is experienced at a collective level.

Once the pool of meaning is populated, the next stage in the constitution of the categories of description is shifting the researcher's attention from the individual subjects to the meaning embedded in the quotes themselves, the 'pool of meanings' discovered in the data. The interpretation is an interactive process between the 'pool of meaning' and the context of the

research. As a result of the interpretive work, similar fragments are brought together into differing categories. Marton (1986) has described this in concrete terms as follows:

> *"In concrete terms, the process looks like this: quotes are sorted into piles, borderline cases are examined, and eventually the criterion attributes for each group are made explicit. In this way, the groups of quotes are arranged and rearranged, are narrowed into categories, and finally are defined in terms of core meanings, on the one hand, and borderline cases on the other. Each category is illustrated by quotes from the data. ... As the meanings of categories begin to form, those meanings determine which quotes should be included and which should be excluded from specific categories. The process is tedious, time-consuming, labor-intensive, and interactive. It entails the continual sorting and resorting of data. Definitions for categories are tested against the data, adjusted, retested, and adjusted again. There is, however, a decreasing rate of change, and eventually the whole system of meanings is stabilized."*
>
> (Marton, 1986, p. 43)

The process of analysis to produce categories of description is thus complex and researchers are required to immerse themselves in the data as it is important to be able to hold the meaning units in focus simultaneously to be able to work with the themes, structures and logical relationships as they emerge (Collier-Reed, 2006).

The categories of description constituted through this analysis make up the phenomenographic 'outcome space' which is a complex of categories of description comprising distinct groupings of aspects of the phenomenon and the relationships between them (Marton & Booth, 1997). The outcome space is thus a robustly constituted set of logically related categories comprising distinct groupings of aspects of the phenomenon. These categories of description are qualitatively different from each other and represent the variation in the way of experiencing the phenomenon.

Furthermore, structural themes give organisation to the categories, both in terms of the internal structure, as well as the structural relationship between them. These themes are also referred to as 'themes of expanding awareness' to highlight the structural relationships

between the different dimensions of variation or categories of description (Collier-Reed, 2006). These themes emerged through an iterative process that involved analysing the quotes from the transcripts, looking for structure and order.

The researcher has noted that as the interviews and survey design drew on specific theoretical frameworks, relating to the research questions and literature, and were formulated using specific language belonging to these frameworks, the answers provided and quotes extracted and added to the 'pool of meaning' were nuanced to reflect these ideas, which have influenced the emergence of the relevant themes, for both the respondents as well as the researcher.

4.4 Chapter Summary

This chapter has described the methods employed in all aspects of this investigation to ensure that the data collected and analysis was robust and related to users reflecting on their experience of PI systems and the effect on their behaviour, mindful self-awareness and sense of sustained wellbeing. The data collection strategy was discussed, including an outline of how the survey and interview question guides were designed and how the participants were selected. The phenomenographic data analysis process was further discussed in detail. The following chapter will present the results of the phenomenographic analysis of the data collected using the methods developed in this chapter.

5 RESULTS AND FINDINGS

5.1 Introduction

Chapter 4 discussed the methods used in this investigation to facilitate exploration of users' description of their experience of PI systems in relation to behaviour change for wellbeing and how principles and effects of behavioural economics and mindfulness (persuasive and mindful design strategies) surface throughout these experiences – the research questions developed in Chapter 1.

This chapter presents the results and findings of the phenomenographic analysis of the data collected using these methods. As the outcomes of a phenomenographic study essentially answer research questions related to the categories of experience of a phenomenon, it is common practice to combine research results and findings, presented by means of the phenomenographic outcome space which outlines these categories of experience (Collier-Reed, 2006; Marks, 2012).

This chapter begins presenting the phenomenographic outcome space in tabular form. The full outcome of the analyses is presented in detail thereafter. The details included in the presentation of the results contain a description of the qualitatively different ways in which the phenomenon is conceived and experienced by means of a set of categories of description. In phenomenographic terms, these categories represent the referential (or meaning) aspect of the outcome space constituted by the results. Thereafter, overlaying attitudinal themes that run through and help characterise the categories, are described. These themes not only provide a more granular description of the categories in relation to the second research question, but also define the structural relationship between the categories and, hence, the structure of the outcome space, by revealing similarities and differences within and between the categories. Examples of most pertinent quotes from respondents extracted from the interview transcripts to substantiate the emergence of categories and themes. The chapter is concluded with a more granular contextualisation of the outcome space in relation to the research questions outlined in Chapter 1 and implications.

5.2 The Phenomenographic Outcome Space

Summary of the outcome space

The table below describes the outcome space for how users experience engagement with PI systems in relation to behaviour change for wellbeing. The table consists of three columns. The first column is representative symbols, the original labelling given to each of the hierarchical categories that each denotes a qualitatively unique way of experiencing the phenomenon; each symbol represents a category of description (COD). The label representing an interpreted categorical meaning of each COD is shown in the second column. The final column draws on the structural themes developed in the analysis to describe each COD in more granular depth. The rows in the table are hierarchically related with each successive row showing a higher 'quality' of experience, indicating increasing levels of lasting behaviour change and sustained wellbeing.

Table 3: Phenomenographic categories of description of the qualitatively different ways in which people experience PI system engagement in relation to behaviour change for wellbeing

COD	Meaning	Focus	Structure
I	PI system engagement in relation to behaviour change for wellbeing is experienced as **forceful and authoritative**.	PI system engagement is experienced as coercive and authoritarian. Although the user does express a recognised need for a supportive structure, the relationship is often strained and experienced as punitive and often unfair or inaccurate. This leads to low levels of trust and display of characteristics such as rebellion, cheating and undermining behaviours. Focus is on external validation through incentives such as physical rewards, competitive measures and numerical goals while little attention is paid to the connection with personal wellbeing and effects of resulting activities on wellness and how to improve. Intrinsic motivation is thus seen to be low. As such the system experience can be interpreted as dictatorial, policing and partial, adding volatility and complexity to the pursuit for sustained wellbeing.	PI system engagement is driven by an external force with some form of external evaluation or validation attached, e.g. reward or a numeric goal. The experience is detached from the essential objective of wellbeing and attached to an external incentive or directive. Behaviour change for wellbeing is volatile and reactive, temporary, irrelevant and often extreme and/or undermining. Characteristics of cheating and rebellion are displayed. Resulting activities are forced, seen as a duty, and low levels of 'in the moment' enjoyment are experienced due to a begrudging undertone. Users experience little identification or engagement with personal data, other than evaluative metrics, specifically from the perceived authoritarian system. No self-reflection or connection with actual wellbeing occurs. Effects on wellbeing are fleeting, irrelevant and often undermining.
II	PI system engagement in relation to behaviour change for wellbeing is experienced as **social and instructive**.	PI system engagement plays a guiding and instructive role in fulfilling the responsibility of maintaining and promoting personal wellbeing. The systems available are seen as support mechanisms and a level of authority that could be described as "libertarian paternalistic" (Thaler & Sunstein, 2008) is assigned to the PI system of choice by the user. Users thus welcome or 'opt in' to being steered and instructed towards reaching goals wellbeing related goals, which are conventional or prescribed. As such, there are expectations from the system to add value to users' lives through relevant instruction and education to positively impact standard wellbeing outcomes, e.g. weight loss, increased activity and better sleep. As such the system is experienced as a mentor and an instructive guide in the pursuit for	PI system engagement is driven by a combination an intrinsic desire for improved wellbeing and an acknowledgement of the need for external monitoring, education, instruction and motivation. The experience is thus one of expectation to be educated, supported and instructed. External validation through system driven motivation mechanisms play a role here in terms of numeric goals or counts, public sharing and social comparisons of results and media (e.g. photographs and videos). Behaviour change for wellbeing is reactive to instruction and appropriate. Resulting activities can be experienced as more structured, and healthy levels of enjoyment are experienced through a sense of progress, achievement and community. Social sharing and personal expression form an important aspect of the experience. Users experience curious engagement with the PI system of choice and their personal data

		sustained wellbeing.	available. Although evaluative metrics form an important part of the account, greater emphasis is placed on information related to the essential objective of wellbeing. Prior use and knowledge about system features and functionality exists. Effects on wellbeing are significant, initiating new habits, suggesting sustained change.
III	PI system engagement in relation to behaviour change for wellbeing is experienced as **experimental and collaborative**.	PI system engagement forms part of a greater personal practice, an existing and established focus of the individual on maintaining and promoting their personal wellbeing. The systems available are seen as tools that facilitate these practices and users experiment and find ways that work for them, personally, to support their subjective priorities, goals and processes related to what wellbeing means for them personally. As such the system is experienced as a collaborator and a deeply personalised facilitator in the eudaimonic pursuit.	PI system engagement is a self-initiated, free enquiry driven by an intrinsic motivation within a personally defined context and manor. The experience forms part of an established relationship that the user has with his or her own wellbeing and the PI system is experienced as a medium, which supports this intrinsic dynamic. Behaviour change for wellbeing is responsive and relevant. Resulting activities are experienced as meaningful; high levels of enjoyment and satisfaction are experienced. Users experience deep identification or engagement with their personal information, through a conscious process of investigation, gaining self-knowledge which synthesises changes in behaviour through engagement. Deep levels of self-inquiry and reflection occurs with a balanced, mindful disposition to self-observation. Effects on wellbeing are deep, relevant, continuous, iterative and sustaining.

Variations in how people experience PI system engagement in relation to behaviour change for wellbeing

This section presents the results of the explorative study that focuses on users' experience of PI system engagement in relation to behaviour change for wellbeing and how the experience of persuasive and mindful design strategies surface throughout these experiences.

The outcome space constituted from the data consists of three qualitatively different categories of description. These categories form a logical hierarchy of increasing sophistication and complexity (from I to III) in the way people experience engagement with PI systems in relation to behaviour change for wellbeing. The categories are described in full in the following section with reference to the structural themes that run throughout the

categories. The structural relationships between the categories of description are presented in terms of the structural themes that run through the categories in parallel.

Categories of description and structural themes

In this sub-section, the characteristics of each category are described in detail. The categories have been given names that reflect the meaning central to each. Extracts from interview transcripts are used to illustrate aspects of each category. For each extract, bold italics are used for what is considered as key phrases. As typical in a phenomenographic study, illustrative extracts cannot encapsulate the whole of a category, but rather can only illustrate critical aspects of a category. Extracts presented are by no means conclusive but serve as strong examples that support the argument for the meanings and structural themes assigned.

PI system engagement in relation to behaviour change for wellbeing is experienced as:

I. Forceful and authoritative
II. Social and instructive
III. Experimental and collaborative

The list above, being hierarchical, suggests that each successive category includes the experience of the previous category. Higher categories of experience often include the experiences listed in the lower categories and are thus not merely a culmination of the experiences of the lower categories but exhibit demonstrably different ways in which PI systems are experienced. Having stated that, it must be noted that individual respondents often display experiences from the full range of categories and themes throughout their experience.

The relationship within and between the categories of description above determines the 'structure' of the experience. This structure is characterised by themes that serve to both qualitatively link and differentiate the categories of experience. The structural themes that were constituted in this analysis are drawn upon to describe the categories of experience below.

Table 4: Phenomenographic outcome space depicting categories of description of the qualitatively different ways in which people experience PI system engagement in relation to behaviour change for wellbeing and structural themes

	PI system engagement in relation to behaviour change for wellbeing is experienced as		
COD / Themes	Forceful and Authoritative	Social and Instructive	Experimental and Collaborative
Motivation / Driver	External directive or incentive Highly persuasive	Interplay between internal and external motivation – persuasion & reflection	Self-initiated free enquiry intrinsically motivated – highly reflective
Attitude & Behaviour	Reactive, volatile, temporary, often, undermining	Responsive to instruction, appropriate and balanced	Responsive to personal insights
Mindful Self-Awareness	Low levels of interest in personal data and self-observation	Encouraging levels of curiosity and fascination with personal data	Deep engagement through investigation of personal data and self-observation
Effects on Wellbeing	Fleeting, irrelevant and often undermining	Significant, habits change, suggesting sustained change	Deep, relevant, continuous, iterative and sustaining

5.2.1 Category I: PI System Engagement in Relation to Behaviour Change for Wellbeing is Experienced as Forceful and Authoritative

PI system engagement is driven by persuasive tactics and generally experienced as coercive and authoritarian in nature. Although the user does express a recognised need for a supportive structure, the relationship is often strained and experienced as punitive and often unfair or inaccurate. This leads to low levels of trust and display of characteristics such as rebellion, cheating and undermining behaviours. Focus is on external validation through incentives such as physical rewards, competitive measures and numerical goals while little attention is paid to the connection with personal wellbeing and effects of resulting activities on wellness and how to improve. Self-reflection and intrinsic motivation is therefore seen to be low. As such, the system experience can be interpreted as dictatorial, policing and partial, adding volatility and complexity to the pursuit for sustained wellbeing.

Theme 1: Driver

PI system engagement is driven by an external force with some form of external evaluation or validation attached, for example reward or a numeric goal. Low levels of reflective engagement and present moment self-awareness are exhibited. The experience is detached from the essential objective of wellbeing and attached to external incentives or directives. Behaviour change is thus highly dependent on persuasive tactics and UX design strategies, which drown out mindfulness states.

> Respondent: **You become too dependent on it or it begins to rule your life** in a sense, so it is about … you have to have some way of determining what are the limits for you …
> - Respondent 10 (58-year-old male clinician, **Arrhythmia sufferer,** Vitality Active Rewards and Apple Watch user)

> Researcher: Do you feel better for it? (Tracking using Garmin and Active Rewards)
> Respondent: Initially, no, **I was, like, why are you forcing me to change my behaviour?**
> - Respondent 8 (43-year-old male CEO, triathlete, Vitality Active Rewards and Apple Watch user)

Theme 2: Attitude & Behaviour

Behaviour change for wellbeing is volatile and reactive, temporary, irrelevant and often extreme and/or undermining. Characteristics of cheating, rebellion, and 'healthism' are displayed with evidence of feelings of anxiety, anger and demotivation. Resulting activities are forced, seen as a duty, and low levels of 'in the moment' enjoyment are experienced due to a begrudging undertone. Respondents speak of neurosis, anxiety and feelings of panic. One respondent tracks card entry swipes at the gym as opposed to actual physical activity and becomes irate and demotivated when these 'goals' are not met, to the extent that it affects his personal life and relationship.

> Respondent: The more I kind of was concerned about the arrhythmia the worse it got. I'm just presuming that being ... ***seeing an actual physical reading of my heart rate would have also contributed*** [to the arrhythmia getting worse] … ***It makes one neurotic, sort of*** … constantly made aware of the threats that we face … health, sleep, all sorts of things that you're

constantly not meeting your targets … I think too much of it can cause a bit of status anxiety … ***so whether it actually improves a person's sense of wellbeing or creates an anxiety.***

*- Respondent 10 (58-year-old male clinician, **Arrhythmia sufferer,** Vitality Active Rewards and Apple Watch user)*

Respondent: What is going on here? ***I panic.*** But again, I'm oversensitive to it because ... ***I need to be doing this well and all of a sudden I'm not*** … There's a lot at stake… ***That's pretty hard ...***

- Respondent 1 (28-year-old female professional triathlete)

Respondent: I must now walk every day … I actually was hundred points short on Friday so I think we went to have a meal on Friday, we did or didn't go to a movie, I can't quite remember, and then I thought I must turn this, and ***I charged to the gym to go and swipe quickly and it was just after nine and the gym closes at nine o'clock on a Friday, so I missed out last week.***

Researcher: So you drove to the gym at after nine o'clock on a Friday night.

Respondent: ***To swipe.***

Researcher: And they were closed. How did you feel? How did that affect your 'wellbeing' on a Friday night?

Respondent: ***Ugh, not much, I mean what was bad for my wellbeing is the fact that I was once again scolded at for being obsessed, not right in my head and eccentric and …***

…

Respondent: No, I'm ***gatvol*** you know, and Saturday the whole day I had something on, and Saturday night I was tired, so I didn't even feel like going to swipe ***and you see that's what Friday did to me.*** If I was up to date Friday I could swipe and I could do what I wanted to do and which I calculated to do in a sense, because I thought they're open until ten o'clock, they were always open until ten o'clock except for, I think, Sunday evenings, but eight o'clock or something, so my whole week ***I haven't done anything now.***

- Respondent 12 (72-year-old male retiree, Vitality Active Rewards and Apple Watch user)

Theme 3: Mindful self-awareness

Users experience little identification or engagement with personal data, other than evaluative metrics, specifically from the perceived authoritarian system. Low levels of mindfulness, self-reflection and self-awareness of actual wellbeing are evident. Engagement with persuasive strategies overwhelm or drown out mindful awareness, sometimes leading to personal injury, undermining wellbeing.

Researcher: If you had to complete this sentence: your tracking activity promotes a sense of ...

Respondent: ***Desire to complete goals.*** When I don't track it promotes a sense of calmness for me, interestingly enough. The moment I run without a watch I'm in a very different mindfulness state than when I do track. It's very interesting. ***When I track I will set a goal and I will achieve it, when I'm not tracking I'm running to how I'm feeling and how I'm thinking.***

... The way I've seen it go bad is when I've set targets racing, either running or cycling, and I've put myself into hurt to get there, tearing a ligament, etc., and I've done those things …

- Respondent 8 (43-year-old CEO, triathlete, Vitality Active Rewards and Apple Watch user)

Respondent: I do think the body has ways of telling you, and I think the problem with tracking and some sort of external indicators of what your targets should be ***override your internal mechanisms and that could be injurious ...***

… My cousin actually got stress fractures because he was trying to meet some ridiculous target.

... People misinterpret what the target is and how you should achieve it and they overdo things and then … you set a target and you want to kind of overshoot that target all the time. ***I think that's one of my concerns, that what does it do to people when they begin to ignore their internal feedback mechanisms and use some sort of external ...***

*- Respondent 10 (58-year-old male clinician, **Arrhythmia sufferer,** Vitality Active Rewards and Apple Watch user)*

Theme 4: Wellbeing

Effects on wellbeing are fleeting, irrelevant and often undermining, for example an anorexic using MyFitnessPal's features to limit food intake, while a user with a heart condition considers not taking medication that lowers heart rate, to facilitate a higher average heart rate during a workout in order to earn Vitality points.

Respondent: There should be more of an education aspect to these things because the way that I abused it, it was easy to abuse it and I used it like that, ***that's the negative part of it is that I actually used it to limit my calories and to make sure that I wasn't having enough,*** and there wasn't enough of a warning, I don't think, it was just like ...

Researcher: So if you didn't get that warning or push notification that you're not ingesting enough calories, was that in itself a warning for you or failure?

Respondent: That was a failure for me.

- Respondent 4 (28-year-old female personal trainer and recovering anorexic)

Respondent: I know. It shouldn't be a problem for me. I can reach it but I take medication that actually, because it's [indistinct] heart rate ... you see this is where I think that one can run into problems because ***sometimes my inclination is not to take the medication.***

Researcher: Before the workout?

Respondent: Yes, the day before.

Researcher: ***So you actually consider not taking your meds specifically for that, to earn points?***

Respondent: Well, I'm trying to figure out what's the best thing but I kind of think that you can be ...

Researcher: And it's not rational, it's life or a smoothie.

Respondent: Yes. So ...

*- Respondent 10 (58-year-old male clinician, **Arrhythmia sufferer,** Vitality Active Rewards and Apple Watch user)*

5.2.2 Category II: PI System Engagement in Relation to Behaviour Change for Wellbeing is Experienced as Social and Instructive

PI system engagement plays a guiding and instructive role in fulfilling the responsibility of maintaining and promoting personal wellbeing. The systems available are seen as support mechanisms and a level of authority that could be described as 'libertarian paternalistic' (Thaler & Sunstein, 2008) is assigned to the PI system of choice by the user. Users thus welcome or 'opt in' to being steered and instructed towards reaching wellbeing-related goals that are conventional or prescribed. As such, there is an expectation from the system to add value to users' lives through relevant instruction and education to positively impact general wellbeing outcomes, for example, weight loss, increased activity and better sleep. As such, the system is experienced as a mentor and an instructive guide in the pursuit for sustained wellbeing.

Theme 1: Driver/Motivation

PI system engagement is driven by a combination an intrinsic desire for improved wellbeing and an acknowledgement of the need for external monitoring, education, instruction and motivation. The experience is thus one of expectation to be educated, instructed, motivated and supported. External validation through system-driven motivation mechanisms play a role here in terms of numeric goals or counts, public sharing and social comparisons of results and media (photographs, videos, etc.). One user experiences smartphone apps as a friend or expert in the palm of his hand, while another appreciates the motivational power of the social nature of certain apps, i.e. Strava.

Respondent: Like the modern world is all about comparison, measurements, tracking, and what these apps do is they draw us into our own world, they do not force us to go into the world outside. ***An app does what a doctor does, an app does what a call centre does, an app does what your friend would do or an expert that you could consult.***

- Respondent 6 (39-year-old male retired professional cyclist and sales manager)

Respondent: Strava (with a Garmin) is the universal cycling app … it's about that ***community peer pressure and competition … Social comparisons*** is the genius of Strava – pitting all cyclists against each other in both collegial and race-like competitiveness – ***it's a very***

effective driving force.

– Respondent 7 (45-year-old male CEO, avid cyclist and social media enthusiast)

Theme 2: Attitude & Behaviour

Behaviour change to support wellbeing is appropriate and responsive instruction. Resulting activities can be experienced as more structured, and healthy levels of enjoyment are experienced through a sense of progress, achievement and community. Social sharing and personal expression form an important aspect of the experience. One user experiences her Polar heart rate monitor as a supportive friend who keeps her accountable to her daily exercise goal while another views Strava (coupled with Instagram) and its photo-sharing features as a communal visual diary of sorts shared with friends, followers and the general public across social platforms.

Respondent: Well, yes, and also I can decide, okay, today I'm running five minutes, or today I'm going take a slow run so I'm going to pace myself and I'm going to run at about five and half minutes, so I basically … before I go home and I run, I know what I'm going to expect and so I can track it.

Researcher: ***So you're setting some kind of clear intention.***

Respondent: ***Exactly.***

Researcher: ***Before you start running.***

Respondent: ***Yes.***

Researcher: ***You log that before you start the run and that keeps you to that plan.***

Respondent: ***Exactly, yes.*** Because I used to run in a big group and ***that's why I said it's my running friend,*** and when you're in a big group you're more … you can pace yourself better and you run with the group, but when I run by myself, if I don't have my watch I give my everything every single time and so this is just a better way to gauge myself, as long as I don't keep recording things.

*- Respondent 4 (28 year-old female personal trainer and **recovering anorexic**)*

Respondent: Taking pictures is a part of my cycling – I tend to mark each ride with a photo uploaded to Instagram and often the same pic to Strava too … ***I use pictures to mark every ride. It's certainly become a motivator for riding – I get to enjoy both of my passions***

simultaneously, not to mention the obvious pious humble-bragging factor associated with #WYMTM (What you missed out on this morning).

- Respondent 7 (45-year-old male CEO, avid cyclist and social media enthusiast)

Theme 3: Mindful self-awareness

Users curiously engage with the PI system of choice and their personal data available. Although evaluative metrics form an important part of the account, greater emphasis is placed on information related to the essential objective of wellbeing. Higher levels of reflection are reported along with an expressed need for instruction and education. Responsiveness and openness to instruction are evident.

Respondent: The Lark app definitely made me want to eat more healthily because when you see the graph at the end of the week of unhealthy to healthy meals, and they're very close … so I thought, oh my gosh, that's terrible, and by the next week you're bridging that gap which is also really nice.

- Respondent 3 (28-year-old female change manager, Vitality Active Rewards and Apple Watch user)

Respondent: The Jawbone, especially the new one, automatically calculates your sleep or monitors it, but it's also quite nice because now I'm trying, because I've been tired the last while, so ***I've been trying to figure out why.*** So it tells me how much sleep I'm getting and that my deep sleep is less than my light sleep, ***but it doesn't tell me how to change that. So it says, okay, well this is your sleep … well, is that good or bad, first of all. That must change to that maybe, if I do a bit of research I can figure that out, but it doesn't give me tips on how to get more deep sleep than light sleep. It doesn't ...***

Researcher: So you were talking about how drinking whiskey before bed, how that affects your sleep and how ...

Respondent: Yes, ***so what I've noticed is that the last day or two, my deep sleep has exceeded my light sleep, which doesn't happen all that often, and I am feeling a little bit better, still a little tired but I still need to push,*** but then you start getting to the point where, okay, now you need to make little changes, but you don't know what they are…

- Respondent 11 (40-year-old male UX specialist)

Theme 4: Wellbeing

Effects on wellbeing are significant, initiating new habits, suggesting sustained change, spilling into other analogous areas of life. One user who was inspired to track during a lecture at school, reports how he has applied an ethos of tracking professional targets and progress for health and fitness goals, with a curious and experimental approach, while another describes in detail how he has changed habits and memorised how many steps he takes when walking instead of driving to places which he visits regularly throughout his day or week, thus significantly changing his lifestyle.

Respondent: I started doing it when I started at the RAA (Raymond Ackerman Academy). We had a lecture with Mr Raymond Ackerman, and he said think it, ink it and implement it. Then repeat the process … ***So this applies to me in my healthy lifestyle, working out, and the business side.*** In business, if you're doing your market research, idea testing, whatever, once you implement that idea and get your feedback from the clients, what they think of the product, you still have to go back and improve the product and do the whole process again. Same applies with health and whatever. ***You have to ... because not all meal plans or diet plans work the same way. You can only know once you've tried it out.***

- Respondent 9 (29-year-old male RAA alumnus, model and entrepreneur)

Respondent: If it wasn't for the watch, I would have stopped at the post office to collect my mail. I'll get out of the car, get it, get back into the car, I would have stopped at Wembley Square ***to quickly swipe and get out again*** at the gym. I would have driven my car there, I would have … there's other stuff to do at Wembley, I would have driven there and stopped because there's more than ample parking, ... ***Now I rather walk and I check and I see, gee, I did a thousand now and I walk to work and I know exactly if I walk to have fish at the Ocean Basket, there and back is four thousand steps. If I walk to Pick n Pay it's almost, it's sixty percent of my goal. If I walk to Checkers, the other side, it's just about my goal.***

- Respondent 12 (72-year-old male retiree, Vitality Active Rewards and Apple Watch user)

5.2.3 Category III: PI System Engagement in Relation to Behaviour Change for Wellbeing is Experienced as Experimental and Collaborative

PI system engagement forms part of a greater personal practice, an existing and established focus of the individual on monitoring, maintaining and promoting their personal wellbeing. The systems available are seen as tools that facilitate these practices and users experiment and find ways that work for them to support their subjective priorities, goals and processes related to what wellbeing means for them personally. As such, the system is experienced as a collaborator and a deeply personalised facilitator in the eudaimonic pursuit.

Theme 1: Driver/Motivation

PI system engagement is a self-initiated, free enquiry driven by an intrinsic motivation within a personally defined context and manner. The experience forms part of an established relationship that the user has with his or her own wellbeing, and the PI system is experienced as a medium which supports this intrinsic dynamic of personal reflection and development of self-knowledge and understanding.

> Respondent: It does feel like things are sort of more in control, not the *gaga* meaning of control, just … yes, and grounded is also such a cliché word, but it's like contained somehow, ***I'm containing myself by checking in …***
>
> *- Respondent 2 (35-year-old female estate manager)*

> Respondent: It was very encouraging initially to run with my phone in my hand, because I didn't have any other gadgets, and to at the end of the run see how far, how fast … ***but what I found awesome about it then,*** a very simple RunKeeper, ***was I could write how it felt.*** That was almost more important to me, I had a niggle in my knee, these shoes are … whatever, oh, I see after twenty minutes I only actually get warmed up, and, you know, things start going. ***So that mindful …sort of, like, another dimension of it was very useful to me.***
>
> *- Respondent 2 (35-year-old female estate manager)*

Theme 2: Attitude & Behaviour

Behaviour change to promote wellbeing is interactive, responsive and relevant. High levels of curiosity, self-compassion and neutrality are observed. Resulting activities are experienced as meaningful; high levels of enjoyment and satisfaction are experienced and good wellbeing-related outcomes are reported, such as weight loss, improved fitness, connection to community and environment.

Respondent: For me personally, I'm fascinated by it because **I often even watch my own behaviour and I'm fascinated by how rational and irrational I can sometimes be.**

- Respondent 8 (43-year-old male CEO, triathlete, Vitality Active Rewards and Apple Watch user)

Respondent: … I'll try and get in as many steps as possible there but there's no point trying to beat anything because the next day I might have no meetings and I sit at my desk.
Researcher: So there's no judgement or good or bad, you don't label good or bad days, just what it is.
Respondent: It is what it is and ***… like I said, it just makes me more conscious of it but I don't try and beat anything … just generally, it just keeps on reminding me to be healthier, a healthier ecosystem.***
Researcher: Do you feel healthier for it?
Respondent: It's getting there, definitely. ***My weight has come down quite significantly***, I am starting to ...
Researcher: How much weight have you lost?
Respondent: ***I was ninety-three at the start of this year. I'm now down to eighty-six."***

- Respondent 11 (40-year-old male UX specialist)

Respondent: Always when you walk, you walk into somebody ***and it's so enriching to then just talk and hear a new story of somebody else's perspective on something or whatever***.
It's amazing how instead of sitting in your car, you're not talking to anybody and just getting gatvol for the taxis, you know?

- Respondent 12 (72-year-old male retiree, Vitality Active Rewards and Apple Watch user)

Theme 3: Mindful self-awareness

Users experience deep identification or engagement with their personal information, through a conscious process of investigation, gaining self-knowledge, which synthesises changes in behaviour through engagement. Deep levels of self-inquiry and reflection occur, with a clear and balanced, mindful disposition to self-observation. The learning and experience garnered from past engagement is applied even after tracking activity ceases.

> Respondent: All of my cycling habits (the actual riding, measuring, communing, photographing) certainly ***make me hyper-vigilant of both myself and my community*** – from a performance and growth perspective but, importantly, from a sense of community too. ***This sense is a major factor in contributing to my feeling of wellbeing.***
>
> - *Respondent 7 (45-year-old male CEO, avid cyclist and social media enthusiast)*

> Respondent: The last two years of my career I didn't have a watch on – heaven. So that was very extreme. I sort of started by default, but then I did quite like it … but at the same time, like I said, I've been at the other extreme as well where I did try and quantify as much as I could.
>
> Researcher: So was it a bit of a reaction against that?
>
> Respondent: My devices got stolen and then sort of ... but I think the principle is ***there's a lot of value in subjective feedback and so quantifying numerically is one way, but if one is able to get to a place where you can quantify a lot that isn't measurable, I think there's great value in that as well, and if you override, perhaps that intuitive feedback mechanism with a desire to achieve metrics, it can be detrimental,*** which is what I was saying at the beginning. There are pros and cons to both. There will always have to be a balance.
>
> - *Respondent 5 (30-year-old male retired professional triathlete, global sports marketing manager)*

Theme 4: Wellbeing

Effects on wellbeing are deep, relevant, continuous, iterative and sustaining. The users' relationship with tracking method of choice is embracing and trusting and the user recognises

and appreciates value that the practice adds to life in various significant, eudaimonic ways, indicating a lasting habit.

> Respondent: ***I'm a lot more balanced because I'm able to reflect and see*** ... I used to do things that I couldn't necessarily track and because I wasn't tracking it, I pushed myself too hard, and now that I'm tracking I get a sense of things are more balanced and it's okay...
> *- Respondent 4 (28-year-old female personal trainer and recovering anorexic)*

> Respondent: Since I had the watch, I'm committed to reach my targets and it's nice that I easily on the beach walk and walk fast and talk to people. It's like a social thing. ***In seven months I walked on the beach more than what I've walked on the beach in the past 20 years – since I've lived here. I think so.***
> *- Respondent 12 (72-year-old male retiree, Vitality Active Rewards and Apple Watch user)*

Outcome space summary

This section has presented the findings of the current study. Using both the phenomenographic approach, the data transcripts of ten interviews with respondents selected through a filtering process done by means of an online survey yielded three categories of description with four dominant structural themes.

The categories of description were as follows: PI system engagement in relation to behaviour change that promotes wellbeing is experienced as:

I. Forceful and authoritative
II. Social and instructive
III. Experimental and collaborative

The dominant themes that served to contextualise four categories of description were interpreted as follows:

I. Driver/motivation
II. Attitude and behaviour
III. Mindful self-awareness
IV. Effect on wellbeing

The relationship between the dominant themes and categories of description gave rise to the outcome space, a matrix illustrating sixteen thematic relationships. These thematic relationships were presented as above and depicted through pertinent quotations from the interviews, which serve to exemplify and emphasise central aspects of these relationships.

5.3 Contextualising Outcome Space in Relation to the Research Questions

The following section will serve to contextualise the phenomenographic outcome space presented above in relation to the research questions in more granular detail and providing a deeper exploration of the research findings.

Chapter 1 presented the research questions, which focused on understanding users' experiences of personal informatics (PI) systems that promote behaviour change for wellbeing and understanding the interplay between behavioural economics and mindfulness principles in this domain, specifically:

1. What are the qualitatively different ways in which people experience personal informatics system engagement that promote behaviour change for improved wellbeing in the context of the changing health paradigm?
2. How are established principles of behavioural economics and mindfulness applied and incorporated in the design and experience of personal informatics systems?

5.3.1 Primary Research Question

What are the qualitatively different ways in which people experience personal informatics system engagement that promote behaviour change for improved wellbeing in the context of the changing health paradigm?

The phenomenographic analyses revealed a set of three qualitatively different categories of experience of engagement with PI systems.

Broadly, the results of this study suggest that the qualitatively different ways in which people experience personal informatics system engagement (that promote behaviour change for improved wellbeing in the context of the changing health paradigm), are:

I. Forceful and authoritative
II. Social and instructive
III. Experimental and collaborative

Structural themes of expanding awareness further assist in defining these hierarchical variations of user engagement, delineating the ways in which users perceive and respond to system engagement, drivers of changes in behaviour, referring to persuasive and reflective drivers, depth and quality of engagement with personal informatics, levels of self-awareness, and the nature of the effect on wellbeing. Structural themes are thus distilled to:

I. Driver/motivation
II. Attitude and behaviour
III. Mindful self-awareness
IV. Effect on wellbeing

Furthermore, the categories of experience could be collapsed further into two broader classifications, specifically low-quality, shallow engagement and high-quality, deepening engagement. The same themes run throughout, indicating shifts from extrinsic to intrinsic motivation, reactive to responsive behaviour change, increasing levels of mindful self-

awareness and more enduring states of wellbeing. A continuum of sophistication of user engagement with PI systems is thus evident, with superficial, reactive, mindless and fleeting at the one end and deep, responsive, mindful and sustaining at the other. The adapted outcome space below includes a depiction of this continuum.

Table 5: Outcome space depicting categories of experience, structural themes and two broader categories of the engagement continuum

	PI system engagement in relation to behaviour change for wellbeing is experienced as		
COD Themes	Forceful and Authoritative	Social and Instructive	Experimental and collaborative
Motivation/ Driver	External directive or incentive Highly persuasive	Interplay between self and system motivation – persuasion and reflection	Self-initiated free enquiry – highly reflective
Attitude & Behaviour	Reactive, volatile, temporary, often, undermining	Responsive to instruction, appropriate and balanced	Responsive to personal insights
Mindful Self-awareness	Low levels of interest in personal data and self-observation	Encouraging levels of curiosity and fascination with personal data	Deep engagement through investigation of personal data and self-observation
Effects on Wellbeing	Fleeting, irrelevant and often undermining	Significant, habits change, suggesting sustained change	Deep, relevant, continuous, iterative and sustaining
	Continuum		
	Low Quality Shallow	High Quality Deepening Engagement	
	Extrinsically motivated reactive behavioural Δ	Increasingly intrinsically motivated responsive behavioural Δ	
	Low mindful self-awareness	Increasing mindful self-awareness	
	Fleeting states of wellbeing	Enduring states of wellbeing	

5.3.2 Secondary Research Question

How are established principles of behavioural economics (BE) and mindfulness applied and incorporated in the *design* and *experience* of **personal informatics systems**?

Design:

The literature outlined in Chapter 2 suggests that BE insights are applied in practice to form part of a broader framework, referred to as Persuasive Design. Mindfulness principles are incorporated in a complementary framework, referred to as Mindful or Reflective Design.

The landscape analysis (Appendix B) discusses in detail how persuasive design strategies (along with established principles of BE) and mindful design strategies are applied in PI system design.

Experience:

The phenomenographic analysis revealed how these behaviour change strategies surface in users' descriptions of their experience. The categories of description serve as tiered classifications of user experience with PI systems, presenting a continuum of user engagement. This continuum reveals diminishing reliance on persuasive strategies, in parallel with increased engagement with reflective design strategies, resulting in greater mindful self-awareness.

At the one end of the continuum, the least sophisticated PI system engagement (Category I engagement) is dominant. This type of user engagement relies heavily on persuasive strategies (which include behavioural economic strategies) leading to a relationship that is experienced by the user as controlling and dictatorial. As such, changes in behaviour that relate to wellbeing are extrinsically motivated, frequently volatile and reactive, often fleeting, irrelevant, contra productive and even injurious in certain cases. Low levels of reflection and mindful engagement by users are thus evident.

Conversely, as the continuum progresses, quality and depth of engagement (Category II and III) increase. More sophisticated PI system engagement reveal a relationship which is guiding, collaborative and experimental, with diminishing reliance on persuasive tactics and increased spontaneous engagement with mindful design strategies, signifying a reflective practice and resulting mindful self-awareness, which complements intrinsically motivated behavioural shifts.

It is noted that these more sophisticated types of engagement frequently still entail interaction with persuasive strategies, but in a generally less attached and often playful manner. However, here interaction with persuasive tactics appear to enhance the experience, making it more enjoyable and more intuitively integrated with broader, meaningful aspects for the users' life, thus suggesting supportive structure to an enduring tracking practice. This is in contrast with engagement that is conditional and dependent on persuasive strategies, as is evident in lower categories of engagement.

Nonetheless, each category of engagement is viewed as valuable in and of itself. Even engagement at the least sophisticated level, although more volatile, indicates levels of proactivity, openness, desire for change and betterment in users. The mechanisms to which they respond serve as a hook that initiates a relationship, which then has potential to advance, creating an opportunity to foster more sophisticated ways of engagement in a captive audience. This is not only an opportunity, but also a responsibility that rests on product designers of PI systems, which aim to support wellbeing of users.

A deeper understanding of the mechanisms at play which support and foster these respective types of user engagement, is necessary to provide insight into implications and application of this work, and specifically, how these strategies can be applied in more considered and strategic ways to design more intuitive systems which nudge users along on the continuum of engagement towards more sophisticated ways of interacting to foster lasting behaviour change and more sustained states of wellbeing.

5.3.3 Summary of Key Insights

The findings presented above are summarised by the following insights:

A complex and multifaceted continuum of user engagement exists

A continuum of increasing quality and depth of user engagement with personal informatics is evident. Stages on the continuum are characterised by varying and improving:

- Quality/depth of personal informatics engagement
- User/system relationships

- Motivations
- Attitudes and behaviour-change responses
- Mindful self-awareness
- Inherent wellbeing outcomes

This continuum of sophistication of user engagement displays superficial, reactive, mindless and fleeting behaviour changes at the one end, and deep, responsive, mindful and sustaining shifts at the other.

The importance of a complementary approach to applying persuasive and mindful design strategies

Findings suggest that an artful balance of persuasive and reflective strategies in system and user experience design can be applied to support users along a continuum of PI system engagement, to progressively lead to more lasting behaviour change and ultimately more enduring states of wellbeing through the cultivation of higher levels of mindful self-awareness.

6 DISCUSSION

6.1 Introduction

This chapter provides a discursive synthesis of the insights produced by this study, its resulting phenomenographic outcome space and academic literature, in response to the research problem and research questions developed in Chapter 1.

In short, the research problem presented the need for a responsible, user-centred approach to personal informatics (PI) system design, informed by an understanding of behavioural economic (persuasive) and mindful (reflective) strategies, to circumvent adverse effects and to better support lasting behaviour change and more enduring states of wellbeing.

The research questions stated are as follows:

1. Primary Research Question

What are the qualitatively different ways in which people experience personal informatics PI system engagement that promote behaviour change for improved wellbeing in the context of the changing health paradigm?

2. Secondary Research Question

How are established principles of behavioural economics and mindfulness applied and incorporated in the **I. Design** and **II. Experience** of personal informatics (PI) systems.

The results of the phenomenographic analyses undertaken to facilitate answering the research questions developed in Chapter 1, were presented in Chapter 5. A landscape analysis is presented in Appendix B to provide further context and offer artefacts for reference.

These results and contextual references reveal insights which hold significant implications, offering important considerations for strategic approaches to PI system design, which is geared at producing user-centred products that support behaviour change and more enduring states of wellbeing, and that form an integral part of a greater Systems Medicine ecosystem and a P4 approach.

To directly address the research problem stated in Chapter 1 and to illustrate function of the theory, implications and application are presented and demonstrated in Chapter 7 by means of an adaptation of an existing model and a prototype design of a personal informatics (PI) system is presented, demonstrating the usefulness of the research and its implications for design, as garnered throughout this inclusive, user-centred process, enabled by a phenomenographic approach.

6.2 Discussion

The primary research question of this study initiated an enquiry into the qualitatively different ways in which people experience personal informatics system engagement that promote behaviour change for improved wellbeing in the context of the changing health paradigm. The phenomenographic outcome space revealed a set of three qualitatively different categories of experience of user engagement with PI systems, in relation to behaviour change and promotion of wellbeing:

I. Forceful and authoritative
II. Social and instructive
III. Experimental and collaborative

These categories of experience will be discussed in detail in the following section. The secondary research question invited an exploration of how established principles of behavioural economics and mindfulness are evident in the design and user experience of PI systems. The literature reviewed in Chapter 2 suggests that BE insights in this context are applied in practice to form part of a broader framework, referred to as persuasive technology or design. Mindfulness principles are incorporated in a complementary framework, referred to as mindful or reflective technology or design (Epstein, Cordeiro, Bales, Fogarty, & Munson, 2014; Gao, 2012; Li, et al., 2011; Li, Dey, et al., 2010; Li, Forlizzi, et al., 2010; Munson, 2012a, 2012b). During the phenomenographic data analysis, respondents' descriptions of their experience were therefore assessed according to their accounts of their responses to persuasive strategies (including behavioural economic) as embedded in the

systems with which they engage, as well as their accounts of the effects of system engagement on their mindful self-awareness. Subsequently, certain of the phenomenographic outcome space's structural themes that emerged, correspond to these frameworks, providing insight into how these dynamics are evident in the categories of user experience and engagement continuum. This means that the hierarchical variations of user engagement delineate motivators for changes in behaviour, including persuasive (including BE) drivers and reflective (mindful) drivers, and effects on lasting behaviour change and ending wellbeing. The landscape analysis (Appendix B) further explores how persuasive (along with established principles of BE) and mindful design strategies are applied in selected examples of PI system design.

The discussion that follows explores the phenomenographic outcome space, its categories of description, relevant structural themes, and engagement continuum in greater detail, with reference to persuasive and mindful frameworks and other literature.

6.2.1 Primary Research Question: The Categories of Experience

I. Category I: PI system engagement in relation to behaviour change for wellbeing is experienced as forceful and authoritative

Table 6: Outline of Category I user experience

COD	Forceful and Authoritative	PI system engagement is driven by persuasive tactics and generally experienced as coercive and authoritarian in nature. Although the user does express a recognized need for a supportive structure, the relationship is often strained and experienced as punitive and often unfair or inaccurate. This leads to low levels of trust and display of characteristics such as rebellion, cheating and undermining behaviours. Focus is on external validation through incentives such as physical rewards, competitive measures and numerical goals while little attention is paid to the connection with personal wellbeing and effects of resulting activities on wellness and how to improve. Self-reflection and intrinsic motivation is thus seen to be low. As such the system experience can be interpreted as dictatorial, policing and partial, adding volatility and complexity to the pursuit for sustained wellbeing.
Motivation / Driver	External directive or incentive Highly persuasive Extrinsically	PI system engagement is driven by an external force with some form of external evaluation or validation attached, e.g. reward or a numeric goal. Low levels of reflective engagement and present moment self-awareness is exhibited. The experience is detached from the essential objective of wellbeing and attached to external incentives or directives. Behaviour change is thus highly dependent on persuasive tactics and UX design strategies, which drown out mindfulness states.

	motivated	
Attitude & Behaviour	Reactive, volatile, temporary, often, undermining Reactive behavioural shifts	Behaviour change for wellbeing is volatile and reactive, temporary, irrelevant and often extreme and / or undermining. Characteristics of cheating, rebellion, and 'healthism' are displayed with evidence of feelings of anxiety, anger and demotivation. Resulting activities are forced, seen as a duty, and low levels of 'in the moment' enjoyment are experienced due to a begrudging undertone. Respondents speak of neurosis, anxiety and feelings of panic. One respondent tracks card entry swipes at the gym as opposed to actual physical activity and becomes irate and demotivated when these 'goals' are not met, to the extent that it effects his personal life and relationship.
Mindful Self-Awareness	Low levels of interest in personal data and self-observation	Users experience little identification or engagement with personal data, other than evaluative metrics, specifically from the perceived authoritarian system. Low levels of mindfulness, self-reflection and self-awareness of actual wellbeing are evident. Engagement with persuasive strategies overwhelm or drown out mindful awareness, sometimes leading to personal injury, undermining wellbeing.
Effects on Wellbeing	Fleeting, irrelevant and often undermining	Effects on wellbeing are fleeting, irrelevant and often undermining. Effects on wellbeing are fleeting, irrelevant and often undermining. For example, an anorexic using MyFitnessPal's features to limit food intake, while a user with a heart condition considers not taking medication that lowers heart rate, to facilitate a higher average heart rate during a workout in order to earn Vitality points.

Driven by persuasive tactics and often described as coercive and authoritarian, Category I user experiences involve a consensual submission to an external structure to discipline and manage behaviour with a degree of personal responsibility transferred to the system of choice. The relationship could thus be described as authoritarian or paternalistic, but with a libertarian slant (Thaler & Sunstein, 2008).

The research thus suggests that due to the paternalistic experience of the relationship as observed in Category I, users may be naturally driven to rebel against an external locus of control over time. Libertarian paternalistic systems (Thaler & Sunstein, 2008), as described in Chapter 2, are seen by some as intrusive and a 'grey area' which can easily become non-paternalistic and coercive in interpretation and design (Schiavone, De Anna, Mameli, Rebba, & Boniolo, 2014), giving rise to a 'bullying' user experience, further contributing to the above-mentioned demotivating effects. This is evident in the way respondents describe their experience with these systems in Category 1.

On the lower end of the continuum, engagement and changes in behaviour are driven by an external outcome, evaluation or validation. Here users rely heavily on behavioural economic and other persuasive strategies. Behaviour change is thus highly dependent on persuasive

strategies, such as incentives, goal progress and loss aversion (AlMarshedi, Wanick, Wills, & Ranchhod, 2016; Amir & Ariely, 2008; Dolan, et al., 2012; Kahneman & Thaler, 2006; Kamenica, 2012; King, Greaves, Exeter & Darzi, 2013), in the form of external rewards, points, numeric values, status, recognition and salient displays of goal progression. When goals are not reached or points or rewards are not achieved, relationships and attitudes decay, motivation diminishes and behaviour changes often cease.

Etkin (2014) cautions that measurement and incentives (tangible, virtual or numeric) can lead a user to associate a 'fun' or 'leisure' activity, with work, diminishing enjoyment and spontaneous engagement, due to the shift of focus to quantification, corroding intrinsic motivation. Gamification studies also suggest that the effect of quantification and gamification on motivation may not be long-term, cautioning that removing persuasive tactics might have detrimental effects to those users who are already engaged in gamification, possibly due to loss aversion from losing, for instance, earned points, badges or rewards (Hamari, Sarsa & Koivisto, 2014). This is particularly evident in the user experiences grouped in Category I, for example, the effect on users affected by the Vitality Active Rewards points changes, as outlined in Appendix B (Landscape).

This is also evident in the concerns raised by Van Dijk et al. (2015), cautioning against reductionist assessment that can lead to counter-productive behaviour changes. A kind of cheating can be caused by reductionist measurement in PI systems due to attention drawn to the raw data parameter, distracting attention from the relevant underlying concept. For example, to reach a numeric goal, users can shake a Fitbit step counter instead of walking, use a GPS cycling tracker like Strava while driving in a car to achieve a 'King of the Mountain' status and gain social standing. They could swipe a card at a gym to imply a workout activity has been performed to earn Vitality points to reach an Active rewards goal to earn a beverage reward and to avoid a loss such as having to pay a penalty on the Apple Watch benefit. Furthermore, these external incentives - which include measurement (Etkin, 2014) - can lead to distorted use of PI system features. For example, default categories in a diet tracker, where users have been observed logging food types such as cheesecake as a protein, or tomato sauce as a vegetable. Used in this way, self-tracking perpetuates, rather than addresses, undermining behaviours.

Viewed through the lens of the Data, Information, Knowledge, Wisdom (DIKW) models (Ackoff, 1989; Bernstein, 2009; Liew, 2013), users' experiences and action are driven by data and information – numbers and symbols – assigned with value, measurement, numeric goals, virtual and non-virtual rewards and other external incentives, which have not been meaningfully contextualised to produce self-knowledge, understanding and significant or profound behavioural shifts. Engagement is observed to be unconscious or mindless and detached from purpose, context and the essential objective of wellbeing.

Following on from this point, Category I clearly exhibits experiences, which are detached from the essential objective of wellbeing. Engagement with persuasive strategies – including these numbers and symbols – is prioritised and overpowers or drowns out mindful awareness, even to the extent of resulting in personal injury in extreme cases, explicitly undermining wellbeing.

Further stark parallels exist with the concept of two brains and System 1 and 2 thinking styles (Kahneman, 2011) as introduced in Chapter 2. Category I engagement suggests predominantly System I reactions while Category II and III demonstrate increasing System 2 responses. These experiences reflect "mindless", less "awake" states of habitual, reactive functioning (Brown & Ryan, 2003), where users tend to grasp for validation and direction from external sources.

Long-term effectiveness of relying on persuasive tactics and System 1 thinking to instil new behaviour and sustained wellbeing, in real-world settings, is evidently problematic, based on the volatile nature of Category 1 experiences. The depth of the learning experience and the long-term effectiveness of BE strategies are also questioned by Dolan, et al. (2012) and Stibe and Cugelman (2016). Kahneman's (2012) work suggests that training our minds to consciously engage in System 2 thinking promotes the natural ability to make better choices, act and behave better more effortlessly, reducing reactivity and enactment on System 1 responses. In other words, exercising the reflective, controlled part of our minds expands cognitive and attention capacity, i.e. rationality, making us less susceptible to mental or ego depletion which leads to irrational reactions and destructive behaviours, driven by the automatic, uncontrolled part of our minds. The research findings emphasise the risks of locking a user into a persuasive dynamic, and creating reliance thereon, suggesting that it can undermine the development of vital functions of System 2, such as self-control, planful action, rational choice and mindful self-awareness, also defied as forms of free will, the

capacity for self-control and intelligent decision-making (Baumeister et al., 2008). Evidence for the benefits of – inherently mindful – System 2 engagement is directly related to fulfilment of the basic psychological needs for autonomy (self-endorsed or freely chosen activity), competence and relatedness (Brown & Ryan, 2003; Brown et al., 2007), key components of eudaimonia – a sustainable state of wellbeing (Botella et al., 2012; Ryan, Huta, & Deci, 2008; Wiederhold & Riva, 2012). The high reliance on persuasive tactics and extrinsic motivators, volatility in behavioural changes and users' relationship with the system as evident in Category 1, are therefore in stark contrast with Ryan et al.'s (2008) model for eudaimonia – a life of purpose and wellbeing – which draws on self-determination theory, and emphasises four motivational concepts:

- Pursuing intrinsic goals and values for their own sake, rather than extrinsic goals and values
- Behaving in autonomous, volitional, or consensual ways, rather than heteronomous or controlled ways
- Being mindful and acting with a sense of awareness
- Behaving in ways that satisfy basic psychological needs for competence, relatedness, and autonomy.

We therefore observe how quantifying beneficial activities impacts users' approach to these activities, and secondly, how extrinsic factors impact intrinsic processes. Findings show that external rewards can undermine intrinsic motivation, and while quantifying or measurement does not provide explicit external incentives for engaging in an activity, it nevertheless produces similar outcomes and which can make these activities be experienced as work. Measuring how much one does, therefore, has the potential to make users dependent on external validation, be it goal completion, social recognition, a virtual or non-virtual reward or even avoiding a loss. Consequently, this can distract from the full depth and meaning of the experience, affecting mindfulness and in-the-moment enjoyment, constraining spontaneous and continued use, and ultimately reduce subjective wellbeing.

One can further deduct that external incentives can divert or distract users from recognising the value of participating in the activity in its own right, thereby reducing enjoyment and depriving the user of experiencing the inherent satisfaction of doing the activity, in and of

itself, eroding not only intrinsic motivation, but also a mindful stance of curiosity and openness to the greater context of the activity.

It is thus clear that persuasive techniques and extrinsic motivators should not be relied on as the sole drivers for changes in behaviour as this can be detrimental to numerous long-term wellbeing outcomes. However, the potential exists to strategically and intuitively apply persuasive techniques to skilfully nudge Category I user engagement towards higher categories. Persuasive tactics can therefore be valuable in motivating adoption of an activity, and should ideally lead users to realising its intrinsic value and subsequent continued engagement without the need for rewards or extrinsic motivation.

II. Category II: PI system engagement in relation to behaviour change for wellbeing is experienced as social and instructive

Table 7: Outline of Category II user experience

COD	Social and Instructive	PI system engagement plays a guiding and instructive role in fulfilling the responsibility of maintaining and promoting personal wellbeing. The systems available are seen as support mechanisms and a level of authority that could be described as "libertarian paternalistic" (Thaler & Sunstein, 2008) is assigned to the PI system of choice by the user. Users thus welcome or 'opt in' to being steered and instructed towards reaching goals wellbeing related goals which are conventional or prescribed. As such, there is an expectation from the system to add value to users' lives through relevant instruction and education to positively impact general wellbeing outcomes, e.g. weight loss, increased activity and better sleep. As such the system is experienced as a mentor and an instructive guide in the pursuit for sustained wellbeing.
Motivation/ Driver	Interplay between self and system motivation – Persuasion & Reflection	PI system engagement is driven by a combination an intrinsic desire for improved wellbeing and an acknowledgement of the need for external monitoring, education, instruction and motivation. The experience is thus one of expectation to be educated, instructed, motivated and supported. External validation through system driven motivation mechanisms play a role here in terms of numeric goals or counts, public sharing and social comparisons of results and media (photographs, videos, etc.) One user experiences smart phone apps as a friend or expert in the palm of his hand while another appreciates the motivational power of the social nature of certain apps, i.e. Strava.
Attitude & Behaviour	Responsive to instruction, appropriate and balanced	Behaviour change to support wellbeing is appropriate and responsive instruction. Resulting activities can be experienced as more structured, and healthy levels of enjoyment are experienced through a sense of progress, achievement and community. Social sharing and personal expression form an important aspect of the experience. One user experiences her Polar heart rate monitor as a supportive friend who keeps her accountable to her daily exercise goal while another views Strava (coupled with Instagram) and its photo-sharing features as a communal visual diary of sorts shared with friends, followers and the general public across social platforms.
Mindful Self-	Encouraging levels of	Users curiously engage with the PI system of choice and their personal data available. Although evaluative metrics form an important part of the account,

awareness	curiosity and fascination with personal data	greater emphasis is placed on information related to the essential objective of wellbeing. Higher levels of reflection are reported along with an expressed need for instruction and education. Responsiveness and openness to instruction is evident.
Effects on Wellbeing	Significant, habits change, suggesting sustained change	Effects on wellbeing are significant, initiating new habits, suggesting sustained change, spilling into other analogous areas of life. One user who was inspired to track during a lecture at school, reports how he has applied an ethos of tracking professional targets and progress for health and fitness goals, with and curious and experimental approach while another describes in detail how he has changed habits and memorised how many steps he takes when walking instead of driving to places which he visits regularly throughout his day or week, thus significantly changing his lifestyle.

At the mid-section of the continuum, we observe users for whom engagement is driven by a more dynamic interplay between external validation and internal drivers. As such, PI system engagement is driven by a combination of an intrinsic desire for improved wellbeing and an acknowledged need for external monitoring, education, instruction and motivation. The users' expectation of the system is to be supported by education and instruction to achieve personal goals related to their wellbeing. As such, the relationship could be described as more *libertarian* paternalistic (Thaler & Sunstein, 2008) than Category I – which borders on coercive – as there is greater appreciation of and value placed on the premise of being steered and instructed towards reaching conventional or prescribed wellbeing-related goals.

Here there is therefore greater symmetry with the idea that coordinated action is the test of possessing knowledge (Zeleny, 2006); action driven by system engagement is based on useful data that has been contextualised and given greater meaning, falling into the information and knowledge categories on Ackoff's (1989) data to wisdom continuum.

As such, there are expectations from the system to add value to users' lives through relevant instruction and education to positively impact wellbeing outcomes. The user's relationship with the system is thus described as mentor/mentee and the system plays a part of an instructive guide in the user's pursuit of sustained wellbeing.

Incentives still play a significant role in Category II engagement, but external validation in the form of rewards and goal progress play a less dominant role than Category I. Other persuasive tactics that surface in Category II engagement, that play an important part in the cultivation of more lasting behaviour change and new habits are those that leverage social and self-expressive aspects. From a behavioural economics perspective, these can be

described as tactics that draw on the BE principles of messenger, norms, commitment and ego (Dolan et al., 2012).

These tactics are supported by social integration features in PI systems, where broader community data is syndicated to provide tactical messaging to motivate behaviour. For example, Headspace displays how many other community members are cycling, running or meditating at any given time. This creates a social norm which influences users to do the same. Furthermore, following the behaviour of others may also produce positive reinforcement through the feeling of being a part of something without much effort or real interaction (Dolan et al., 2010). Strava applies the same premise by displaying how many other athletes in a user's network are training at any given time. The platform further taps into the principle of 'messenger' by using messaging from prominent influencers (professional athletes) to set examples, encouraging participation and motivating improved performance. It also leverages the principle of 'ego' by means of leaderboards, allowing users to compete with athletes from across the Strava community. Salience is leveraged through the advanced media-sharing capability that enables users to upload images of their rides or runs directly from the camera apps on their phones and even from the Instagram app. These features are explored in greater detail in Appendix B.

These tactics appear to be so effective, partially because of the rising culture of sharing through status updates, media sharing, etc., brought about by the growing social media phenomenon of the past 10 years and ubiquitous technologies (Christensen, 2013). Publicly keeping track of daily activities has become common practice for many, and activities logged on platforms like Strava (and even Instagram) could be compared to more traditional practices of note taking or journaling, bringing greater awareness to events and actions. Even when there is no specific goal set or users are not explicitly striving to improve performance or health outcomes, these forms of tracking bring a form of mindful awareness to relevant activities. Furthermore, habits of documenting activities over time enable retrospective reflection, progress tracking and pattern recognition. These public mechanisms tap into persuasive strategies of ego and commitment (Dolan et al., 2012; Thaler & Sunstein, 2008). They create a supporting virtual environment and a culture with a broader community of participants and stakeholders, which provide nudges toward behaviour promoting wellbeing and healthier ways of being, in more integrated and dynamic ways than Category I,

suggesting more lasting change and the formation of an ecosystem which supports sustained states of wellbeing.

Category II user engagement therefore resonates with the third classification of Positive Technology (PT) and third level of 'positive human functioning' - the social and interpersonal level ((Riva et al., 2012), as outlined in Chapter 2. Social interaction that leads to collaborative and participatory growth is an integral function of these PT systems and Category II user experiences, which are often characterised by high receptiveness to social expressional and public affirmation. Connections between individuals in these networked communities foster what is described as a 'net-shared-self' which has the potential to transcend limits of individualism and rationalism for certain users. Sharing goals and achievements is a significant source of personal reward and social belonging. This sense of connectedness promotes perseverance toward goals. Further, contributions from networked communities shape, influence and enhance users' personal identity and sense of self.

However, drawing on studies of motivation and Self-determination Theory, people driven by ego and extrinsic aspirations, such as image or fame, have been shown to have fewer experiences that are supportive of growth tendencies that lead to wellbeing and integration, exhibiting behaviour that undermines exactly that, often displaying neurosis, anxiety and depression (Kasser & Ryan, 1996; Ryan et al., 2008). As such, the reliance on social dynamics as evident in Category II is a possible cause of the relative volatility observed here, in comparison with Category III. The public nature of data-sharing can further compromise the accuracy and authenticity of the image projected by the user, further posing a risk of producing the antithesis of the DIKW model as introduced in Chapter 2 (Bernstein, 2009).

Moreover, the reliance on instruction from PI systems, as observed in Category II, is a further source of caution. Generally accepted views about the capabilities and accuracy of technology as well as the image of users that they present, are not necessarily reflections of reality (Van Dijk et al., 2015). The dependence and trust that users place in these systems, in terms of relying on them for an accurate reflection of their wellbeing as well as for instruction and insight, are a reason for concern. Self-tracked data presented to reflect a simple relationship with underlying behaviour and physiological processes, can be deceptive. Over-dependence can lead to the belief that data provided by the systems offer a more dependable and objective view than users' own subjective experience, even when the

reflection is distorted, enhanced or reductive. As such, over-trust can lead users to disregard their actual experience over data and media. Users appear to risk becoming addicted to the affirmation provided by these systems, feeling detached or under-informed when data is not available. Furthermore, users appear to risk experiencing things as 'real' only if they have been tracked, not recognising achievements as valuable unless they have been recorded by an objective external system.

This over-trust may cause feedback from PI systems to dictate subjective experience of users. For example, if a sleep-tracking device indicates to the user they have not slept well, they might internalise that view, feeling less productive and more tired as a result. The same line of reasoning may lead to positive outcomes if the picture painted by the self-tracking data is more positive than the user expected. This over-trust once again alludes to extrinsic drivers.

To circumvent the threats inherent in social and instructive Category II dynamics, the researcher draws on Gaver, Beaver, & Benford (2003), who contend that PI systems design should incorporate principles of ambiguity to indicate the uncertainty of the underlying data and system interpretations, and to impel people to question for themselves the truth of a situation, to encourage deeper engagement and to incite and more honest and accurate analytical use and interpretations of personal data. This alludes to the progression towards a Category III experience.

III. Category III: PI system engagement in relation to behaviour change for wellbeing is experienced as experimental and collaborative

Table 8: Outline of Category III user experience

COD	Experimental and collaborative	PI system engagement forms part of a greater personal practice, an existing and established focus of the individual on monitoring, maintaining and promoting their personal wellbeing. The systems available are seen as tools that facilitate these practices and users experiment and find ways that work for them, personally, to support their subjective priorities, goals and processes related to what wellbeing means for them personally. As such the system is experienced as a collaborator and a deeply personalised facilitator in the eudaimonic pursuit.
Motivation / Driver	Self-initiated free enquiry – Highly Reflective	PI system engagement is a self-initiated, free enquiry driven by an intrinsic motivation within a personally defined context and manor. The experience forms part of an established relationship that the user has with his or her own wellbeing and the PI system is experienced as a medium which supports this intrinsic dynamic of personal reflection and development of self-knowledge and understanding.
Attitude &	Responsive to	Behaviour change to promote wellbeing is interactive, responsive and relevant.

Behaviour	personal insights	High levels of curiosity, self-compassion and neutrality are observed. Resulting activities are experienced as meaningful; high levels of enjoyment and satisfaction are experienced and good wellbeing related outcomes, such as weight-loss, improved fitness, connection to community and environment are reported.
Mindful Self-Awareness	Deep engagement through investigation of personal data and self-observation	Users experience deep identification or engagement with their personal information, through a conscious process of investigation, gaining self-knowledge which synthesises changes in behaviour through engagement. Deep levels of self-inquiry and reflection occur, with a clear and balanced, mindful disposition to self-observation. The garnered from past engagement is applied even after tracking activity ceases.
Effects on Wellbeing	Deep, relevant, continuous, iterative and sustaining	Effects on wellbeing are deep, relevant, continuous, iterative and sustaining. The users' relationship with tracking method of choice is embracing and trusting and the user recognises and appreciates value that the practice adds to life in various significant, eudaimonic ways, indicating a lasting habit

The research findings depict ways in which various PI systems are woven into the lives of users who are, intentionally or not, filling the gaps in cognitive decision-making, sensory and awareness systems, informing and guiding them. In Category III behavioural shifts result from being supported in gaining insight and understanding of existing behaviour and its (often quantifiable) effects. This category of experience represents the most sophisticated level of engagement, best exemplifying the ethos of the Quantified Self community – "self-knowledge through numbers". Data is thought of as "a mirror", a platform for reflection, learning, and personal insight (Wolf, 2010). Engagement thus forms part of an established relationship that the user has with his or her own wellbeing, and the PI system is experienced as a medium which supports this intrinsic dynamic.

An important distinguishing aspect of this category is therefore levels of mindful self-awareness (as explored in Chapter 2) observed in the attitude of users. These attitudes are characterised by curiosity – defined as present-moment awareness with an investigative interest – and decentring, defined as shifting from identifying personally with pieces of information, seeing them as passing mental events rather than ingrained reflections of reality. Mental experiences and sensory information appear to be cognitively monitored, with a less evaluative stance, and users report being attentive to current experience and functioning, thus indicating mindfulness (Vacca & Hoadley, 2016). In Category III, we further observe how awareness and attention are powerful mechanisms for change. By simply becoming aware of what is occurring within and around users, they appear to start a process of disentangling themselves from negative habits and states of mind, including mental preoccupations

(ruminative thinking), difficult emotions (emotional suffering or discomfort) and maladaptive reactions (automatic behaviours) (Siegel, R.D., Germer, & Olendzki, 2009). This contrasts strongly with 'mindless', less 'awake' states of habitual, reactive functioning (Brown & Ryan, 2003) as prevalent in Category I and also observed in Category II, where users tend to grasp for validation and direction from external sources.

PI system engagement is a self-initiated, free and experimental enquiry. The incentive or purpose of engagement is an intrinsic desire to make personally relevant connections and identify patterns, all within a personally defined context and manner. Engagement is thus deeply personal and relevant and intrinsically driven. An intimate, collaborative relationship exists between the user and the PI system of choice. Furthermore, interaction reinforces the user's relationship with him or herself through a reflective practice that yields a better personal understanding of the working of the mind and body. This is likened to Siegel's (2010) description of the function of reflective practices to create structure and order, cultivating deeper self-awareness and a more mindful approach, leading to greater wellbeing.

The prevalence of reflective, System 2 engagement is directly related to fulfilment of the basic psychological needs for autonomy (self-endorsed or freely chosen activity), competence and relatedness (Brown & Ryan, 2003; Brown et al., 2007), key components of eudaimonia – sustainable state of wellbeing (Botella et al., 2012; Ryan et al., 2008; Wiederhold & Riva, 2012). High levels of engagement in reflective system constructs tactics and apparent resilience of intrinsic drivers, indicate strong parallels with Ryan et al. (2008)'s model for eudaimonia – a life of purpose and wellbeing and its motivational concepts:

- Pursuing intrinsic goals and values for their own sake, rather than extrinsic goals and values
- Behaving in autonomous, volitional, or consensual ways, rather than heteronomous or controlled ways
- Being mindful and acting with a sense of awareness
- Behaving in ways that satisfy basic psychological needs for competence, relatedness, and autonomy.

The research findings suggest that Category III PI system engagement supports mindful awareness and, like more traditional mindfulness practices (Brown & Ryan, 2003; Brown et al., 2007), when intuitively designed, may play a role in the fulfilment of human needs for autonomy (self-endorsed or freely chosen activity), competence and relatedness. This occurs, through greater self-awareness, insight and subsequent ability to act in ways that are conducive to success and wellbeing (Brown & Ryan, 2003).

Referencing the DIKW models, increasing engagement sophistication along the continuum indicates deeper user interaction with personal information, resulting in knowledge, leading to insight and understanding, and ultimately wisdom and action, in parallel with expanding levels of mindful self-awareness (Liew, 2013). Category II displays these observations through an apparent desire to learn, viewing the system as a coach, guide or mentor, with increasing levels of curiosity. Category III demonstrates deep, mindful engagement and expanding self-awareness through experimental, investigative and creative self-discovery, which are in accordance with what Liew (2013) describes as "wisdom dimensions".

This kind of engagement, through which information obtained directly through self-experimentation (as opposed to from, for example, a doctor applying a theory that may have general effectiveness at the population level but not at the individual level), is far more meaningful and significantly different, and translates much more expediently to behavioural change and the empowerment of the user (Swan, 2012a).

Mindfulness, in cybernetic terms, was explored in Chapter 2. Reflective, Category III dynamics in PI systems, such as prompts for linguistic expression and personal data visualisations, enable users to reflect on their own behaviour and to observe patterns and create feedback loops that promote adaptive behaviour toward self-organisation and resilience, i.e. health and wellbeing (Garland, 2007; Mazaza, 2015; Schwartz, G.E. 1982; Zeleny, 1981). Second-order cybernetics (Maturana & Francisco, 1987) highlights the influence of the observer in determining the effect of feedback or stimulus, and the fact that, consequently, external feedback does not cause a response but stimulates the individual to shift into one of its own, inherent response patterns. Thus, the response is determined by the individual's own cognitive or self-organisational process. Seen in this light, a mindful or Category III stance, as observed at the higher end of the continuum, may support mindful, adaptive responses and resilience.

Higher category engagement is thus best aligned with the objectives of Positive Technology (PT), as introduced in Chapter 2. PT is defined as the scientific and applied approach for improving the quality of human experience with the goal of increasing wellbeing, promoting strengths, resilience, engagement and meaning in individuals, organisations, and society by means of technology (Botella, et al., 2012). Drawing from the field of positive psychology, positive technology focuses on promoting three key areas of human wellbeing to promote adaptive behaviours and positive functioning in users, specifically emotional quality (hedonic or enjoyment level), engagement/actualisation (eudaimonic or wellness level), and connectedness (social and interpersonal level) (Botella, et al., 2012; Graffigna, et al., 2013; Riva, et al., 2012; Wiederhold & Riva, 2012). Furthermore, to be considered PT, technologies should be designed to improve the quality life, promote wellness and generate resources and strengths in individuals by providing intrinsically satisfying experiences that engage users in a process of continuous development centred on needs for competence, connection, autonomy and optimism (Wiederhold & Riva, 2012).

It must be cautioned, however, that self-focus, self-discovery and increased awareness of parameters being tracked as a result of interaction with PI systems, though beneficial if it leads to actionable insights, can be damaging and undermine wellbeing when taken to the extreme, leading to 'healthism' – a paradoxical, neurotic obsession, as reported by certain respondents. As discussed in Chapter 2, Van Berkel et al. (2015) outline two kinds of attentiveness to one's inner thoughts and feelings. The first is a ruminative style that involves judgment or assessment, the second is described as a philosophically oriented self-reflection. The ruminative style is understood to be maladaptive while the reflective style is presumed more adaptive (Trapnell & Campbell, 1999). Furthermore, it has been found that abstract thinking, about outcomes, meanings and implications, tends to be maladaptive, while concrete thinking about processes and plans makes for better problem solving (Watkins, 2008). This suggests that PI system design aimed at solving practical challenges should seek to avoid a judgemental stance and abstract searches for meaning while seeking to promote deep-thinking reflection, specifically on processes and plans.

Category III engagement suggests a locus of intrinsic motivation through strong identification with personal information through a process of conscious investigation, leading to changes in behaviour through self-experimentation. Deep levels of reflection and self-inquiry thus occur,

with a balanced, mindful disposition to self-observation. The system is described to be experienced as a collaborator and a deeply personalised catalyst in a continuous eudaimonic pursuit, yielding effects on wellbeing that appear to be continuous, iterative and sustaining.

A study by Kasser and Ryan (1996) further confirms that intrinsic versus extrinsic aspirations have a predictable effect on a variety of wellness-relevant outcomes, from subjective happiness to relationship quality, to physical health. Respondents whose aspirations for extrinsic goals and rewards (such as wealth and material possessions, social recognition and fame, and image or attractiveness) were strong relative to those for intrinsic goals and rewards (such as personal growth, affiliation and intimacy, contributing to one's community, and physical health), displayed lower wellbeing on a number of indicators. Further, results revealed that the strength of intrinsic versus extrinsic drivers, as ranked by respondents according to goal importance, was positively related to extensive psychological wellbeing indicators, such as self-actualisation and vitality, and negatively to indicators of 'ill-being', including anxiety, depression, and physical ailments. Similar findings have since been established in studies examining these effects in a number of diverse cultures, demonstrating that the intrinsic/extrinsic goal distinction is relevant across demographics (Grouzet et al., 2005; Schmuck, Kasser, & Ryan, 2000)

The cultivation of intrinsic motivation, aspiration and reward, along with skills related to personal empowerment and mindful self-awareness, is therefore deemed fundamental in supporting wellbeing – eudaimonia and multi-layered human flourishing. The challenging ideal this research proposes for system designers, is thus to create user experiences that aim to develop users' sense of competence, connection, autonomy and optimism, while simultaneously tapping into and enhancing hedonic (enjoyment), eudaimonic (wellness) and social (interpersonal) levels of the experience of the wellness-related activities that these systems encourage.

6.2.2 Secondary Research Question: Persuasive and Mindful Technology

The following section will provide a more direct – though reiterative – response to answer the secondary research question enquiring which established principles of behavioural economics and mindfulness are evident in the design and user experience of PI systems.

The literature reviewed in Chapter 2 suggests that BE insights in this context are applied in practice to form part of a broader framework, referred to as 'persuasive' technology or design (Fogg, 2003; Fritz et al., 2014; Meschtscherjakov, Boris, Fuchsberger, Murer, & Tscheligi, 2016). Mindfulness principles are incorporated in a complementary framework, referred to as 'mindful' or 'reflective' technology or design (Epstein, D., et al., 2014; Gao, 2012; Li et al., 2011; Li, Dey, et al., 2010; Li, Forlizzi, et al., 2010; Munson, 2012a, 2012b). The landscape analysis (Appendix B) discusses in detail how persuasive design strategies (along with established principles of BE) and mindful design strategies are applied in PI system design.

The phenomenographic analysis and discussion above revealed how these behaviour change strategies surface in users' descriptions of their experience. To summarise, at the one end of the continuum, the least sophisticated PI system engagement (Category I engagement) is dominant. This type of user engagement relies heavily on persuasive strategies (which include behavioural economic strategies) leading to a relationship which is experienced by the user as controlling and dictatorial. As such, changes in behaviour that relates to wellbeing are frequently volatile and reactive, often fleeting, irrelevant, counter-productive and even injurious in certain cases. Low levels of reflection and mindful engagement by users are thus evident. Conversely, as the continuum progresses, quality and depth of engagement (Category II and III) increase. More sophisticated PI system engagement reveals a relationship which is guiding, collaborative and experimental, with diminishing reliance on persuasive tactics and increased spontaneous engagement with mindful design strategies, signifying a reflective practice and resulting mindful self-awareness. However, more advanced engagements frequently still entail interaction with persuasive strategies, but in a generally less attached and often playful manner. However, here interaction with persuasive tactics appears to enhance the experience, making it more enjoyable and more intuitively integrated with broader, meaningful aspects for the user's life, thus suggesting supportive structure to an enduring tracking practice. This is in contrast with engagement that is conditional and dependent on persuasive strategies, as is evident in lower categories of engagement.

Each category of engagement is considered valuable in its own right, nonetheless. Engagement at the least sophisticated level, although more volatile, indicates levels of proactivity, openness, desire for change and betterment in users. The mechanisms to which they respond serve as a hook that initiates a relationship that then has potential to advance,

creating an opportunity to foster more sophisticated ways of engagement in a captive audience. This is not only an opportunity, but also a responsibility that rests on product designers of PI systems, which aim to effectively the support wellbeing of users.

A deeper understanding of the mechanisms at play which support and foster these respective types of user engagement, is necessary to provide insight into how these strategies can be applied in more considered and strategic ways to design more intuitive systems which nudge users along on the continuum of engagement towards more sophisticated ways of interacting to foster lasting behaviour change and more sustained states of wellbeing.

The field of gamification provides a pragmatic lens through which to understand these mechanisms and interpret the research findings. Gamification[6] broadly refers to the persuasive design approach of using 'gaming' elements to motivate and engage people in non-game contexts, and is increasingly being used in health and behavioural change interventions .King, D., et al., 2013). It is further defined as "a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioural outcomes" (Hamari et al., 2014, p. 3026). The application of behavioural economic principles is clearly evident in gamification (Paharia, 2010). The field thus exemplifies the application of these principles in system, user experience and interface design, offering a valuable pragmatic lens for analysis.

The Mechanics, Dynamics, Aesthetics (MDA) framework (Hunicke, LeBlanc, & Zubek, 2004) applied in game and gamification design, further provides a useful, practical model for the understanding and application of persuasive UX constructs embedded in popular PI systems, as mentioned above. An adaptation of this model, expanded to incorporate mindful/reflective design MDAs will be presented in the following chapter.

[6] Whether knowingly or not, stark overlap exists between gamification and insights from behavioural economics (BE). For example, many games provide conditional rewards (e.g. points and prizes) that risk being lost if gamers do not return frequently to play. This plays on the well-known tendencies of people to avoid losses (loss aversion).

6.2.3 The Engagement Continuum

The three hierarchical categories of experience and the engagement continuum revealed by the phenomenographic outcome space could further be overlaid with various conceptual frameworks introduced in chapter 2 and above.

The Positive Technology domain (Botella et al., 2012; Riva et al., 2012) outlines three levels of engagement, specifically;

- hedonic
- social/interpersonal
- eudaimonic

which respectively target specific experiential features of:

- emotional quality
- connectedness
- engagement/actualisation.

The hierarchical categories of experience and the engagement continuum could be mapped to these levels of engagement, with Category I corresponding to the hedonic level, Category II to the social and interpersonal level and Category III to the eudaimonic level.

Category I; being highly dependent on rewards, recognition and peruasive motivators; could be described as motivated by positive emotional responses to hedonic experiences which are often ego-driven and rely on fleeting thrills and pleasures which reward their actions.

Category II experiences often involve social engagement, social expression and social recognition, and are therefor often driven by a need for connectedness and belonging - as well as competion and status. As such, a level of extrisic reliance through social connection is thus present.

Category III experiences display deep engagement and a desire for actualisation, reflecting eudaimonia, described by Aristotle as true wellbeing which involves a pro-active life of reason, virtue and flourishing (Flanagan, 2011). These experiences provide – and are driven by and the need for - a sense of autonomy and feelings of competence. These characteristics further reflect the self-determination theory perspective of eudaimonia - or living well, which incorporates "pursuing intrinsic goals and values for their own sake; behaving in autonomous, volitional, or consensual ways, rather than heteronomous or controlled ways; being mindful and acting with a sense of awareness; and behaving in ways that satisfy basic psychological needs for competence, relatedness, and autonomy" (Ryan, et al., 2008, p. 139).

Previous sections have further explored specialisations of persuasive technology (and behavioural economics) and mindful/reflective technology as tools to motivate behaviour change. The engagement continuum revealed in the research findings suggests a shift from extrinsic to intrinsic motivation. Intrinsic motivation is described as the internal desire to do things out of a desire for personal fulfilment (AlMarshedi, et al., 2017) and is inextricably linked with eudaimonia/living well/wellbeing, as described above (Flanagan, 2011; Ryan, et al., 2008).

In addition to Self-determination theory (Ryan, et al., 2008) various behaviour change theories, such as 'Tiny Habits' (Fogg, 2011), 'The Flow State' (Csikszentmihalyi, 1997) which is also referenced by Kahneman (2012), and human drivers of autonomy, mastery, and purpose (Pink, 2009) can be applied to nudge user progression along the engagement continuum and to promote development of intrinsic motivation in users. Observations from the research suggest that reflective design strategies can be aligned with insights from these theories to foster intrisic motivation and to better support more enduring states of wellbeing.

As discussed, research findings show that, as the engagement continuum progresses, action is driven by an increasingly dynamic interplay between external and internal drivers, ranging from acknowledgement and reward, social recognition, fellowship, self-expression, self-discovery to self-actualisation, and a more balanced range of system design approaches as referenced in the Mechanics, Dynamics and Aesthetics (MDA) model (Hunicke, et al., 2004) adapted in Chapter 7. Practical examples include goal progress tracking, social interactions, media sharing, reflection on activity data visualisations and spontaneous input of contextual information.

The BE-based 'nudge' theory (Thaler & Sunstein, 2008) could further be applied in system design by providing indirect signals toward non-forced action, by clearly incorporating MDAs with escalating reflective characteristics in system design, initiating a journey toward better wellbeing. As the user progresses and becomes increasingly adept with the system, it intuitively supports deeper engagement, avoids boredom, creates intrigue and stimulates curiosity.[7]

Drawing on the adapted MDA model which will be presented in Chapter 7, the research suggests that MDAs that are associated with higher category user engagement, bear greater relevance in this domain, particularly those that require high levels of manual user-driven engagement, as opposed to system-driven.

For example, Foss (2002) contends that the root of human reflexivity, leading to mindful self-awareness, is the capacity for language, the human ability to reason by 'talking to ourselves', and that through linguistic expression, we learn about ourselves, adapt to our environments, and make our way through the world. The importance of providing mechanisms that encourage users to engage linguistically is thus assumed, in designing for greater reflexivity and mindfulness. An example is text input fields for contextual information, or micro-journaling/blogging. Further, language used throughout PI system UX design, including titles, instructions, prompts and notifications, is another key mechanism that requires strategic consideration to support users along the engagement continuum.

6.3 Chapter Summary

The discussion provided in this chapter linked the research findings with literature discussed in Chapter 2. It also introduced new literature to provide a more pragmatic lens through which to assimilate the findings and facilitate application to answer the research questions and to address the research problem as outlined in Chapter 1.

[7] This is often seen in free vs. premium versions of applications, such as Strava and MyFitnessPal, as well as in mobile applications and web services that also offer ranges of wearables and devices, such as Withings, FitBit, Jawbone and Garmin and Polar.

In addressing the first research question, the qualitatively different ways in which respondents experience personal informatics system engagement (that promote behaviour change for improved wellbeing in the context of the changing health paradigm), and the engagement continuum, as revealed by the phenomenographic outcome space, were discussed.

A synthesis was provided, between current literature and the categories of experience, plotted on a continuum from Forceful and Authoritative, Social and Instructive, to Experimental and Collaborative and given structure by common themes of expanding awareness, delineating the ways in which users perceive and respond to PI system engagement, depth and quality of engagement, drivers of changes in behaviour, referring to persuasive and reflective drivers, levels of mindful self-awareness, and the nature of the effect on wellbeing. Two broader classifications, representing opposite ends of the continuum were discussed, based respectively on low-quality, shallow engagement and high-quality, deepening engagement, indicating shifts from extrinsic to intrinsic motivation, mindless to mindfully self-aware states, suggesting shifts from fleeting to more enduring states of wellbeing.

In addressing the second research question, centred on how principles of behavioural economics (BE) and mindfulness are incorporated in system design and experience, these concepts were collapsed into two defined fields as revealed by the literature, i.e. persuasive and mindful (or reflective) technologies, respectively. The hierarchical nature and structural themes of the phenomenographic outcome space further provided deeper insight into these points. Categories of users' experience – responses and susceptibility to persuasive (including BE) tactics, such as rewards and numeric incentives were discussed in light of literature, as well as the effects of engagement on mindful awareness.

The intricacies of motivational drivers, mindful self-awareness and wellbeing dynamics, as evident in the engagement continuum, were explored in greater depth, revealing the vital importance of designing systems which nudge users toward reflective or mindful engagement in order to cultivate intrinsically driven dispositions and skills (as opposed to extrinsically motivated habits) to optimally support lasting behaviour change and authentic and enduring states of wellbeing – eudaimonia and multi-dimensional human flourishing.

Chapter 7 presents an adaption of the Mechanics, Dynamics, Aesthetics (MDA) framework (Hunicke et al., 2004), which has been adapted to include reflective (mindful) UX constructs. This model provides a possible framework for system designers to facilitate more considered approaches that balance persuasive and reflective (mindful) design strategies.

7 IMPLICATIONS AND APPLICATION

7.1 Introduction

Any further application of the theory developed and categories of description falls outside of a phenomenographic study, although it is methodologically sound to use the outcome space in other studies (Collier-Reed, 2006). The applied nature of the degree (Master of Philosophy specialising in Inclusive Innovation) further deems a deeper exploration of research implications and application appropriate.

The current chapter is a departure from the stated research questions of this thesis and provides a practical application of the theory as well as the phenomenographic outcome space and its categories of description to formulate guidelines for more considered approaches to personal informatics (PI) system design, addressing the research problem stated in Chapter 1 more directly.

7.2 Recontextualising the New Health Care Paradigm

Chapter 2 introduced several alternative medical ontologies that have been proposed by various forerunners in the field in response to a health care system in crisis and the need for a more efficient and sustainable approach than the prevailing, reductionist biomedical model (Engel, 1977, 1980; Foss, 2002; Hood & Flores, 2012; Hood, et al., 2004; Rothenberg & Foss, 1987; Swan, 2009, 2012a). Many recognise Systems Medicine, with information as its fundamental currency as a new and emerging health care paradigm, offering a fundamentally new and far more powerful approach which is already showing promising results in improving the sustainability of health care, through holistic but personalised, quantified, cross-disciplinary approaches, reducing resources required for treatment and recovery (Janetos, 2009; Flores, et al., 2013; Hood & Auffray, 2013; Swan, 2012a). This paradigm is also described as P4 medicine which refers to a shift from reactive disease care to a pre-clinical and patient (person)-centred emphasis that is predictive, preventative, personalised and participatory (Flores, et al., 2013; Hood, 2013; Sobradillo, et al., 2011).

The widespread adoption of PI systems, as observed in this study, is leading to the realisation of many of the ideals held by these early systems approaches. This phenomenon is further contributing to the fulfilment of the vision of the pioneers of Systems Medicine through its increasing pervasiveness and advancing abilities to capture physiological, psychological (behavioural), social and environmental data. In this way it is creating far more complete data sets that increasingly comprehensively measure a full spectrum of health-related aspects, reflecting the complexity of an individual's health, enabling more advanced predictive and personalised capabilities. Extensive interactive features are further enabling proactive engagement by patients and healthy individuals to better understand and manage health and wellbeing, with significant implications for preventative and participatory approaches.

These approaches further hold powerful implications for innovative participatory approaches to addressing (largely preventable) endemic lifestyle diseases that significantly add to the disease burden on the global economy. The dire need for behavioural interventions that appropriately address lifestyle-related disorders more effectively by assisting in management and behavioural shifts was emphasised in Chapter 2 (Becker & Kleinman, 2013; Christie & Yach, 2015; Halpern, et al., 2004; Mulgan, 2006).

However, literature cautions that the participatory component of P4 medicine is the most challenging to implement, as, by its very nature, it requires an inclusive approach that considers complex dynamics among an intricate network of stakeholders. Creation, adoption and continued, appropriate use of personal informatics systems by patients and consumers, are stipulated as essential for reaching a critical mass for large-scale success of P4 medicine. Accurate data collection and integration are outlined as other key requirements (Flores, et al., 2013; Hood & Auffray, 2013).

The insights generated by the research findings suggest that considered application of various design strategies (persuasive and mindful) have a fundamental role to play in addressing the challenges of realising participatory components of P4 medicine. Leveraging advancing data collection and interactive features appropriately through intuitive user experience design strategies that nudge users along a continuum of styles of engagement, is key to the creation of PI system-based behavioural interventions that form part of a Systems Medicine ecosystem. These strategies specifically have a primary role to play in encouraging its

adoption and continued (appropriate) participation, which in turn can support preventative, predictive and personalised directives.

The research suggests that tactical application of system design strategies can facilitate preventative and participatory health care, supporting lasting behavioural changes and more sustained states of wellbeing, in various ways, including:

- Encouraging adoption and continued use;
- Motivational shifts;
- Attitudinal and behavioural shifts;
- Cultivation of reflection leading to mindful self-awareness;
- Cultural shifts; and
- Facilitation of a more transparent patient-clinician relationship.

The shifts and dynamics involved, based on the engagement continuum presented by the phenomenographic outcome space, are explored in the following sections.

7.3 Applying the Outcome Space and its Engagement Continuum

7.3.1 Nudging the Irrational Towards Thinking Slow

The categories of experience outlined in the outcome space are categorised primarily by the broad nature of the relationship which the user has with the system of choice or how this relationship is perceived, i.e. I. Forceful and Authoritative; II. Social and Instructive; III. Experimental and Collaborative. These categorisations indicate receptiveness to varying types or styles of system constructs, ranging from overtly persuasive to subtly reflective constructs. By being cognisant of these predispositions, system designers can use specific tools to design user experiences which are likely to nudge these predictably irrational users towards thinking slow.

For example, Category I reacts primarily to evaluative persuasive constructs, such as status, points, numeric goals and rewards. This is often seen in the volatile relationship respondents

have with platforms such as the Vitality and Active Rewards systems (with its overt status, points goals and reward focus), as well as MyFitnessPal with its prominent numeric focus (calorie goals, consumption and expenditure). Category II and III respond to 'milder' constructs, which indicates increasing levels of mindful engagement. For example, effective Category II features include personalised guidance, social and self-expressive features as seen in Lark and Jawbone with their real-time performance-based push notifications, and Strava with its social comparisons and rich social sharing abilities. Popular Category III features include components that enable reflection such as contextual text fields and detailed personal data visualisations, as evident in respondents' experiences with RunKeeper, Strava and Garmin, as well as MyFitnessPal (though under-utilised).

7.3.2 The MDA Model

User Experience Mechanics, Dynamics and Aesthetics (UX MDA)

The field of gamification provides a pragmatic lens through which to interpret the research findings. Gamification[8] broadly refers to the persuasive design approach of using 'gaming' elements to motivate and engage people in non-game contexts, and is increasingly being used in health and behavioural change interventions (King, et al., 2013). It is further defined as "a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioural outcomes" (Hamari, et al., 2014, p. 3026).

The Mechanics, Dynamics, Aesthetics (MDA) framework (Hunicke, et al., 2004) applied in game and gamification design, provides a useful model for understanding the UX constructs embedded in popular PI systems, as mentioned above. The MDA framework views these constructs as artefacts and thereby practically facilitates understanding of how these techniques are used, enabling iterative design, improvement and control of undesired outcomes, to tune systems for desired behaviour and end user experience.

Figure 6: MDA Framework (Hunicke et al. 2004)

[8] Whether knowingly or not, stark overlap exists between gamification and insights from behavioural economics (BE). For example, many games provide conditional rewards (e.g. points and prizes) that risk being lost if gamers do not return frequently to play. This plays on the well-known tendencies of people to avoid losses (loss aversion).

'Mechanics' describes the practical components at the level of data representation. According to Paharia (2010) these include:

- Points
- Leader boards
- Levels (status)
- Achievement systems rewards and badges (or meta-tasks/auxiliary goals often performed in external systems which get rewarded)
- Virtual goods
- Gifting and charity

Drawing on the research, the following features that support more reflective dynamics could be added to this list of mechanics that are effective at driving behaviour change:

- Real-time feedback
- Content (editorial and educational)
- Data Visualisations (such as progress and performance)
- Contextual text inputs

'Dynamics' describes how mechanics respond to user inputs and the outputs of other mechanics over time (Hunicke, et al., 2004). Dynamics create the motivation behind specific user behaviour fulfilling various common human desires. It is crucial for game and gamification designers to target and satisfy inherent human needs of the different users

Some of these common desires that drive behaviour include:

- *Rewards* that provide affirmation and returns for effort.
- *Status, attention and recognition* that provide prestige and respect.
- *Achievement* that provides a sense of accomplishment, leading to searches for new challenges and setting new achievable goals.
- *Self-expression* that allows people to be unique and distinguishable from others.
- *Competition* that creates dramatic tension and encourages higher levels of performance through comparison with others.
- *Altruism* that satisfies a need to add value or give to others or a community.

Drawing on the research, the following desires are also prevalent in the higher categories of engagement, driving behaviour change:

- *Fellowship* that satisfies a need connection, community – belonging.
- *Knowledge* that satisfies a need to learn and understand.
- *Self-Actualisation* that satisfies a need for fulfilment of personal potential, competence, effectiveness and autonomy.

The table below matches some popular game mechanics to relevant dynamics.

Table 9: Human desires X game mechanics (Paharia, 2010)

	Human Desires					
Game Mechanics	Reward	Status	Achievement	Self-Expression	Competition	Altruism
Points, Badges & Rewards						
Levels						
Challenges						
Virtual Goods						
Leaderboards						
Gifting & Charity						

Suitable mechanic

Most suitable mechanic

'**Aesthetics'** describes the desirable emotional responses evoked in the player, when he or she interacts with the game system. According to the MDA framework, evoking emotional responses enhances users' motivation and engagement. According to Hunicke, et al. (2004), aesthetics includes (but are not limited to) the taxonomy listed here:

- Sensation – Game as sense-pleasure
- Fantasy – Game as make-believe
- Narrative – Game as drama
- Challenge – Game as obstacle course

- Fellowship – Game as social framework
- Discovery – Game as uncharted territory
- Expression – Game as self-discovery
- Submission – Game as pastime

Zarnekow, et al. (2017) articulate that aesthetics represent a hedonic aspect of games and contend that aesthetics should represent the goal of the gamified system and not distract the user from the desired outcome. For example, too challenging – and therefore frustrating – game elements might diminish the user experience and take a negatively affect desired outcomes.

Referencing the phenomenographic outcome space, this is evident in Category I engagement, particularly in respondents' frustration with Vitality Active Rewards and its primary aesthetic of challenge, in which goals are frequently experienced as unrealistic to meet consistently, causing negativity, decrease in enjoyment demotivation and ultimately, drop-out.

Strava combines aesthetics of fellowship (through its social sharing features), challenge (through segment personal bests and leaderboards), discovery (through its unique way of comprehensively making an array of relevant data available to a niche audience), and expression (through advanced personal data visualisations and interactive features) creating a platform which supports Category I to III engagement, making it seamless for a user who is naturally drawn to Category I style engagement to progress along the continuum to higher categories.

7.3.3 States of Play

Applying the Outcome Space and Engagement Continuum to the MDA

When viewing the research findings through the lens of the MDA framework presented above, it becomes clear that specific mechanics, dynamics and aesthetics are more pertinent than others in various categories and stages, playing important roles in influencing user experience across the various facets as indicated by the structural themes. The following

tables indicate specifically pertinent UX mechanics, dynamics (desires) and aesthetics for each category of experience.

Table 10: MDA model adaptation and application to the outcome space: Mechanics

Game Mechanics	Category I	Category II	Category III
Points			
Levels			
Challenges			
Virtual Goods			
Leaderboards			
Gifting & Charity			
Real-time feedback			
Content			
Data Visualisations			
Contextual Text Input			

Table 11: MDA model adaptation and application to the outcome space: Dynamics/Human desires

Game Dynamics / Human Desires	Category I	Category II	Category III
Rewards			
Status, attention and recognition			
Achievement			
Competition			
Self-expression			
Altruism			
Fellowship			
Knowledge			
Self-Actualisation			

Table 12: MDA model adaptation and application to the outcome space: Aesthetics

Game Aesthetics	Category I	Category II	Category III
Sensation – Game as sense-pleasure			
Fantasy – Game as make-believe			
Narrative – Game as drama			
Challenge – Game as obstacle course			
Fellowship – Game as social framework			
Discovery – Game as uncharted territory			
Expression – Game as self-discovery			
Submission – Game as pastime			

Least Relevant

Moderately Relevant

Most Relevant

The adapted and MDA framework, expanded with the pheonomenographic outcomes space and its engagement continuum overlaid, as presented above, offers a useful, practical model for understanding and mapping the array of complex levers available and aspects at play, enabling more considered, systems approaches to strategic PI system design and may provide insight into how these mechanics, dynamics and aesthetics can be applied in practice to facilitate more lasting changes in behaviour and more enduring states of wellbeing.

7.4 Application

Appendix C presents a speculative illustration of how the insights developed during this study and implications presented in Chapter 7 can inform PI system design to support sustained behaviour change for eudaimonic wellbeing and to shift motivation to engage in positive behaviours, from extrinsic incentives and persuasive dynamics, toward more intrinsic, self-organising drivers. Preliminary work undertaken on a prototype design of a customisable PI system that forms part of a branded ecosystem supporting an inclusive business model is presented along with a hypothetic business plan.

The business model includes the white-labelled applications that are customisable according to the specific needs of healthcare providers and professionals. These bespoke applications are geared to form part of clients' treatment plans and programmes, facilitating client engagement in treatment programmes through regular digital check-ins, keeping them on track. It further enables the HPC to monitor clients' progress and assess responses to treatment in fundamentally more comprehensive ways than a traditional consultation, which relies on the client to report progress, symptoms and effects between sessions verbally in limited time.

The white-labelled product offering represents the primary revenue stream and is monetised by means of a range of tiered HPC subscriptions. Packages are differentiated according to the extensiveness of bespoke applications (based on the number of modular MDAs incorporated) and the number of user licences included, based on the size of the HPC's practice.

The prototype presented signifies a white-label application, customised for a specific health care professional to focus on cultivating healthy eating in clients, incorporating a mindfulness

based therapeutic approach developed by therapeutic dietician, Julie Deane-Williams. User interface design is presented, incorporating various reflective (primarily) and persuasive levers (MDAs).

The prototype is given the working title, FoodScape, a sub-brand of an overarching MindScape brand. The MindScape brand vision is to create intrinsically satisfying experiences that engage users in a process of continuous development of greater mindful self-awareness, personal integration and eudaimonic states, supporting holistic wellbeing.

7.5 Chapter Summary

Drawing on the research findings, the role of PI systems in innovative and responsible approaches to health care, specifically Systems (P4) medicine, was discussed in this chapter, outlining the challenges inherent in promoting participatory preventative practices – fundamental pillars of this paradigm. To assist in addressing these challenges, practical application of persuasive and reflective UX strategies were explored through the lens of the Mechanics Dynamics Aesthetics (MDA) model from field of gamification (Hunicke, et al., 2004), which was augmented to include reflective MDAs along with conventional persuasive MDAs. The phenomenographic outcome space and its categories of experience were overlaid to reveal relevance of MDAs to specific categories of user experience, providing a map for system designers to enable considered, strategic approaches and tactical application of MDAs during system design phases, thus addressing the research problem stated in Chapter 1 more directly. A prototype design that incorporates predominantly reflective design strategies, supported by persuasive tactics, as explored in the adapted MDA model was presented to illustrate application.

8 CONCLUSION

8.1 Introduction

Chapter 1 presented the research questions, formulated to inform personal informatics (PI) system design that supports lasting behaviour change and more sustained states of wellbeing and focused on understanding users' experiences of PI systems and the interplay between behavioural economics and mindfulness principles in this domain. Specifically:

1. What are the qualitatively different ways in which people experience personal informatics system engagement that promotes behaviour change for improved wellbeing in the context of the changing health paradigm?
2. How are established principles of behavioural economics and mindfulness applied and incorporated in the design and experience of personal informatics systems?

Chapter 2 presented a review of academic literature from various relevant frameworks, starting with an introduction to inclusive innovation, followed by a contextualisation of the emerging health paradigm and the roles of positive technologies, and specifically personal informatics (PI) systems in this domain. Thereafter the key concepts from the fields of persuasive (including behavioural economics) and mindful technology were discussed, concluding with a further exploration of the meanings of mindfulness and the concept of 'The Observing Self'. Chapter 3 introduced phenomenography as an appropriate research methodology to answer the research questions outlined in Chapter 1. Chapter 4 discussed the method that facilitated the collection of comprehensive data sets. Chapter 5 presented the results and findings of the data analysis and produced the phenomenographic outcome space, supported by brief clarifications and demonstrated by examples of respondents' quotes. Chapter 6 provided a discursive synthesis of the research findings with existing and new literature and explored practical implications and application. Limitations of this study were outlined. Chapter 7 demonstrated usefulness of the theory built throughout this research endeavour through implications and application with the introduction of an adapted Mechanics, Dynamics and Aesthetics model along with a prototype design for brand and product design, supported by an inclusive business model. The following chapter provides a

summary of the theory built in response to the research problem and questions, outlines limitations, suggests areas for future research and offers concluding remarks.

8.2 Contribution

This thesis contributes to a broader understanding of how users experience PI system design that promotes behaviour change and wellbeing, in the context of the emerging health paradigm. Pillars of this paradigm include patient (human)-centric, pre-clinical (preventative) and participatory emphases; enabled by information and communication technologies, specifically for this purpose, PI systems.

In response to the research questions of this study, i.e. how users experience engagement with PI systems, and how principles of behavioural economics and mindfulness surface in these interactions in users' pursuit for wellbeing, a phenomenographical research study was undertaken. The results produced an outcome space, a set of hierarchical categories of description that delineate a range of qualitatively different ways in which people experience PI system engagement – from their perspective.

The tiered categories of experience are mapped on a continuum, from Forceful and Authoritative, to Social and Instructive, to Experimental and Collaborative. Common themes of expanding awareness further define the ways in which users perceive and respond to PI system engagement and suggest two broader classifications, representing opposite ends of the continuum characterised by low quality, shallow engagement and high quality, deepening engagement, indicating shifts from extrinsic to intrinsic motivation, mindless to mindfully self-aware states, suggesting shifts from volatile to enduring states of wellbeing.

Supported by the phenomenographic approach, the interplay between persuasive and mindful user experience (UX) design strategies in system and interface design is explored through users' (and administrators') accounts of combined effects on behaviour change and wellbeing. An adaptation of the Mechanics, Dynamics and Aesthetics (MDAs) model (Hunicke, et al., 2004) from the field of gamification is developed, by mapping popular UX MDAs according to the phenomenographic categories of user experience. The hierarchical relationship between categories provides insight into how specific MDAs could be applied in system design to shift users along an engagement continuum, supporting a progression from

extrinsically motivated, reactive, 'mindless' engagement toward more intrinsically rewarding, responsive, mindful engagement, which implicitly supports more lasting behaviour change and more sustained states of wellbeing. Application of the model is demonstrated in a prototype design, a product that forms part of an inclusive business model with a hypothetical business plan attached.

The theory developed by this study can assist PI system designers and product developers in creating interfaces which support more lasting behaviour change for sustained wellbeing, firstly, by facilitating better understanding about the mechanisms available and, secondly, by assisting more considered and strategic approaches to the application of persuasive and mindful tactics and features in PI system and interface design.

As such, PI systems should be mindful of these dynamics and the need to create digital ecosystems that combine persuasive and reflective MDAs, to guide users along a continuum toward greater self-awareness, using these exosensory systems to refine awareness and to cultivate more mindful ways of being that support lasting behaviour change, while cultivating intrinsic qualities of personal accountability, autonomy, self-reliance, flourishing and fulfillment.

This thesis thus supports the ideal of user interface design that reflects a culture of wellbeing, through language, symbolism and reflectively persuasive user experience, which mindfully nudges users to engage, interact, interpret in a way that is less evaluative, more open and curious, encouraging equanimity, flexibility and integration rather than rigidity, to ultimately lead to enactment of a eudaimonic culture by the users that adopt it.

8.3 Limitations

Certain limitations exist in this study that warrant particular mention.

1. The relevant theoretical frameworks, relating to the research questions and literature, guided the entire research process, from survey design and interview structure to the extraction of quotes and formulation of categories of description and structural themes.

Findings are thus centred on these concepts and may not offer a holistic reflection of the ways in which users experience PI systems in this domain.

2. The study relied on self-reports of wellbeing outcomes from survey and interview respondents and, as such, response tendencies could have influenced the findings. This is evident in the polarised responses to certain survey questions as outlined in greater detail in Chapter 4.
3. Research primarily focused on individuals from one broad socioeconomic group, culture and historical period, specifically health-conscious upper-income individuals who reside in the most urbanised areas in South Africa (Cape Town and Johannesburg). The majority of respondents had medical aid and many were motivated to track specifically by their scheme's strategic programme, which is, in itself, creating a sub-culture of sorts. Findings may thus not be cross-culturally relevant.
4. The relatively small sample size further suggests anecdotal rather than general examples.
5. As per the phenomenographic methodology, all data is cross sectional and correlational so no concrete conclusions about causality can be made.

8.4 Suggestions for Future Research

This study has raised a number of possibilities for future research which are presented below:

1. Mindscape Platform:
    a. A study of the extent to which the MindScape FoodScape platform (as presented in Chapter 7) supports healthier eating habits and improved wellbeing.
    b. A study of the extent to which the MindScape FoodScape platform (as presented in Chapter 7) supports treatment outcomes of eating disorder patients.
    c. A study of the extent to which the MindScape FoodScape platform (as presented in Chapter 7) supports the practice of a healthcare professional.

2. A longitudinal study of the ways in which Discovery Vitality members who have taken advantage of the Active Rewards/Apple Watch benefit have experienced the product and its effects on lasting behaviour change and wellbeing.

3. A study of how a participatory wellness intervention (based on the Discovery Vitality model) might be designed to be relevant in a public health domain.
4. An inquiry into how choice architecture imposed by libertarian paternalistic systems impact beneficiaries' internal resources related to eudaimonic criteria of mindfulness, competence, relatedness and autonomy.

8.5 Final Thoughts

Health care and behaviour science are rapidly evolving and converging with information technology and design. This dynamic nexus holds opportunities for innovation and for design of new systems that profoundly facilitate human wellbeing in ways that transcend the physical absence of illness to include psychological, social and environmental aspects. Thus, with a considered approach to design, these novel PI systems have the potential to mediate a journey within to promote development of higher centres of consciousness to support individual and collective wellbeing. The ultimate vision is better relationships with self, each other and our environment, supporting a more sustainable health care paradigm, which cultivates personal and collective eudaimonic ideals through a continuous process of personal development, centred around wellbeing that transcends the core physical focus to include mindfulness, competence, relatedness, autonomy and hopefulness for the future.

"Perfect objective knowledge of the world cannot be had because there is no objective world. The thing measured is influenced by the measurement"
(Lindley, 1993, p. 62).

BIBLIOGRAPHY

Ackoff, R. L. (1989). From data to wisdom. *Journal of Applied Systems Analysis*, *16*, 3–9.

AlMarshedi, A., Wanick, V., Wills, G., & Ranchhod, A. (2017). Gamification and Behaviour. In S. Stieglitz, C. Lattemann, S. Robra-Bissantz, R. Zarnekow, & T. Brockmann (Eds.), *Gamification - Using Game Elements in Serious Contexts* (pp. 19–29). Cham, Switzerland: Springer. http://doi.org/10.1007/978-3-319-45557-0_2

Amir, O., & Ariely, D. (2008). Resting on laurels: the effects of discrete progress markers as subgoals on task performance and preferences. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *34*(5), 1158–1171. http://doi.org/10.1037/a0012857

Anthony C Janetos. (2009). *A new biology for the 21st century*. *Frontiers in Ecology and the Environment* (Vol. 7). Washington DC, USA: National Research Council: National Academies Press. http://doi.org/10.1890/1540-9295-7.9.455

Ariely, D. (2009). *Predictably Irrational (New and Revised Edition)*. New York, USA: Harper Perennial.

Ariely, D., & Simonson, I. (2003). Buying, Bidding, Playing, or Competing? Value Assessment and Decision Dynamics in Online Auctions. *Journal of Consumer Psychology*, *13*(1&2), 113–123. http://doi.org/10.1207/S15327663JCP13-1&2_10

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., … Williams, J. M. G. (2008). Construct Validity of the Five Facet Mindfulness Questionnaire in Meditating and Nonmeditating Samples. *Assessment*, *15*(3), 329–342. http://doi.org/10.1177/1073191107313003

Banos, O., Amin, M. B., Khan, W. A., Afzal, M., Hussain, M., Kang, B. H., & Lee, S. (2016). The Mining Minds Digital Health and Wellness Framework. *BioMedical Engineering OnLine*, *15*(1), 1–22. http://doi.org/10.1186/s12938-016-0179-9

Baregheh, A., Rowley, J., & Sambrook, S. (2009). Towards a multidisciplinary definition of innovation. *Management Decision*, *47*(8), 1323–1339. http://doi.org/10.1108/00251740910984578

Barnard, A., McCosker, H., & Gerber, R. (1999). Phenomenography: A Qualitative Research Approach for Exploring Understanding in Health Care. *Qualitative Health Research*, *9*(2), 212–226. http://doi.org/10.1177/104973299129121794

Baumeister, R. F., Sparks, E. A., Stillman, T. F., & Vohs, K. D. (2008). Free will in consumer behavior: Self-control, ego depletion, and choice. *Journal of Consumer*

Psychology, *18*(1), 4–13. http://doi.org/10.1016/j.jcps.2007.10.002

Becker, A. E., & Kleinman, A. (2013). Mental Health and the Global Agenda. *The New England Journal of Medicine*, *369*, 66–73. http://doi.org/10.1056/NEJMra1110827

Bellinger, G., Castro, D., & Mills, A. (2004). Data, Information, Knowledge, and Wisdom. Retrieved June 26, 2016, from http://www.systems-thinking.org/dikw/dikw.htm

Bernstein, J. (2009). The data-information-knowledge-wisdom hierarchy and its antithesis. In *Proceedings from North American Symposium on Knowledge Organization (NASKO)* (pp. 68–75). Syracuse, NY. Retrieved from https://journals.lib.washington.edu/index.php/nasko/article/view/12806/11288

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., … Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*(3), 230–241. http://doi.org/10.1093/clipsy/bph077

Blumenthal-Barby, J. S., & Burroughs, H. (2012). Seeking better health care outcomes: The ethics of using the "nudge." *The American Journal of Bioethics*, *12*(2), 1–10. http://doi.org/10.1080/15265161.2011.634481

Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2005). *Handbook of Self-regulation*. San Francisco, California: Elsevier.

Booth, S. (1997). On Phenomenography, Learning and Teaching. *Higher Education Research & Development*, *16*(2), 135–158. http://doi.org/10.1080/0729436970160203

Borrell-Carrió, F., Suchman, A. L., & Epstein, R. M. (2004). The Biopsychosocial Model 25 Years Later. *Annals Of Family Medicine*, *2*(6), 576–582. http://doi.org/10.1370/afm.245

Botella, C., Riva, G., Gaggioli, A., Wiederhold, B. K., Alcaniz, M., Baños, R. M., … Riva, G. (2012). The Present and Future of Positive Technologies. *Cyberpsychology, Behavior, and Social Networking*, *15*(2), 78–84. http://doi.org/10.1089/cyber.2011.0140.

Bowden, J. A., & Walsh, E. (2000). *Phenomenography*. Melbourne, Australia: RMIT University Press.

Bravata, D. M., Smith-Spangler, C., Gienger, A. L., Lin, N., Lewis, R., Stave, C. D., & Olkin, I. (2007). Using Pedometers to Increase Physical Activity A Systematic Review. *JAMA*, *298*(19).

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*(4), 822–848. http://doi.org/10.1037/0022-3514.84.4.822

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical Foundations and Evidence for its Salutary Effects. *Psychological Inquiry*, *18*(4), 211–237.

http://doi.org/10.1080/10478400701598298

Bruce, C. (1999). Phenomenography : Opening a New Territory for Library and Information Science Research. *The New Review of Information and Library Research*, *5*(1), 31–48.

Bui, N., & Zorzi, M. (2011). Health Care Applications : A Solution Based on The Internet of Things. In *International Symposium on Applied Sciences in Biomedical and Communication Technologies (ISABEL)* (pp. 1–4). Barcelona, Spain. http://doi.org/10.1145/2093698.2093829

Chance, Z. (2013, May). Zoë Chance: How to Make a Behavior Addictive [Video file]. Retrieved April 8, 2015, from https://www.youtube.com/watch?v=AHfiKav9fcQ

Chandler, J., Rycroft-Malone, J., Hawkes, C., & Noyes, J. (2016). Application of simplified Complexity Theory concepts for healthcare social systems to explain the implementation of evidence into practice. *Journal of Advanced Nursing*, *72*(2), 461–480. http://doi.org/10.1111/jan.12815

Chang, R. (2015). The Intriguing Intersection of Wearable Technology and Healthcare. Retrieved from http://www.isg-one.com/index/module-article-detail/the-intriguing-intersection-of-wearable-technology-and-healthcare

Chen, F. (2011). Self-Tracking in Mindful Technologies. In *Proceedings of Quantified Self 2011*. Mountain View, California. Retrieved from http://www.slideshare.net/fxchen/mindful-tech-qs2011

Chen, F., Hekler, E., Hu, J., Li, S., & Zhao, C. (2011). Designing for context-aware health self-monitoring, feedback, and engagement. In *Proceedings of the ACM 2011 Conference on Computer supported Cooperative Work - CSCW '11* (pp. 613–616). Hangzhou, China. http://doi.org/10.1145/1958824.1958927

Chin, R. (2000). The Internet : Another Facet to the Paradigm Shift in Healthcare. *Singapore Medical Journal*, *41*(9), 426–429.

Choe, E. K., Lee, N. B., Lee, B., Pratt, W., & Kientz, J. A. (2014). Understanding Quantified-Selfers' Practices in Collecting and Exploring Personal Data. In *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems (CHI '2014)* (pp. 1143–1152). Toronto, Canada. http://doi.org/10.1145/2556288.2557372

Christensen, L. (2013, January). Big-Brother Health or Mindful Living? Quantified Self Organizer Steven Dean on the Difference Between Self-tracking and Surveillance. Retrieved July 27, 2016, from http://www.vanityfair.com/news/2013/01/quantified-self-organizer-steven-dean-interview-surveillance

Christie, G., & Yach, D. (2015). *Ethical , Legal , and Social Implications of Personalized*

Health Technology. New York, USA: Vitality Institute.

Collier-Reed, B. I. (2006). *Pupils ' Experiences of Technology Exploring dimensions of technological literacy*. (Doctoral thesis, Department of Engineering, University of Cape Town, South Africa). Retrieved from http://www.health.uct.ac.za/usr/mecheng/staff/academic/brandon/Collier-Reed2006.pdf

Consolvo, S., Mcdonald, D. W., & Landay, J. A. (2009). Theory-Driven Design Strategies for Technologies that Support Behavior Change in Everyday Life. In *Proceedings of Computer Human Interface Conference - Creative Thought and Self-Improvement (CHI '2009)* - (pp. 405–414). Boston, USA. http://doi.org/10.1145/1518701.1518766

Crane, C., Winder, R., Hargus, E., Amarasinghe, M., & Barnhofer, T. (2012). Effects of mindfulness-based cognitive therapy on specificity of life goals. *Cognitive Therapy and Research*, *36*(3), 182–189. http://doi.org/10.1007/s10608-010-9349-4

Creswell, J. J. (2013). *Qualitative Inquiry and Research Design*. Los Angeles, USA: Sage Publications.

Cullis, P. (2015). *The Personalized Medicine Revolution: How Diagnosing and Treating Disease Are About to Change Forever*. Vancouver, Canada: Greystone Books.

Datta, S., & Mullainathan, S. (2014). Behavioral design: A new approach to development policy. *Review of Income and Wealth*, *60*(1), 7–35. http://doi.org/10.1111/roiw.12093

Dolan, P., Hallsworth, M., Halpern, D., King, D., Metcalfe, R., & Vlaev, I. (2010). *MINDSPACE. Influencing Behaviour through Public Policy*. Full report Cabinet Office. London, UK: Institute for Government.

Dolan, P., Hallsworth, M., Halpern, D., King, D., Metcalfe, R., & Vlaev, I. (2012). Influencing behaviour: The mindspace way. *Journal of Economic Psychology*, *33*(1), 264–277. http://doi.org/10.1016/j.joep.2011.10.009

Dow Schull, N., & Zaloom, C. (2011). The shortsighted brain: Neuroeconomics and the governance of choice in time. *Social Studies of Science*, *41*(4), 515–538. http://doi.org/10.1177/0306312710397689

Du Plessis, M. (2007). The role of knowledge management in innovation. *Journal of Knowledge Management*, *11*(4), 20–29. http://doi.org/10.1108/13673270710762684

Dubberly, H., Mehta, R., Evenson, S., & Pangaro, P. (2010). Reframing Health to Embrace Design of our Own Well-being. *Interactions*, *17*(3), 56–63. http://doi.org/10.1145/1744161.1744175

Duval, E. (2011). Attention please!: Learning analytics for visualization and recommendation. In *Proceedings of the 1st International Conference on Learning*

Analytics and Knowledge (LAK '11) (Vol. 1, pp. 9–17). Banff, Alberta, Canada. http://doi.org/10.1145/2090116.2090118

Engel, G. L. (1977). The Need for a New Medical Model: A Challenge for Biomedicine. *Science*, *196*(4286), 129–136. http://doi.org/10.1126/science.847460

Engel, G. L. (1980). The clinical application of the biopsychosocial model. *The American Journal of Psychiatry*, *137*(5), 535–544. http://doi.org/10.1176/ajp.137.5.535

Epstein, D., Cordeiro, F., Bales, E., Fogarty, J., & Munson, S. (2014). Taming data complexity in lifelogs. In *Proceedings of the 2014 conference on Designing interactive systems (DIS '14)* (pp. 667–676). Vancouver, BC, Canada. http://doi.org/10.1145/2598510.2598558

Epstein, R. M., Siegel, D. J., & Silberman, J. (2008). Self-Monitoring in Clinical Practice: A Challenge for Medical Educators. *Journal Of Continuing Education In The Health Professions*, *28*(1), 5–13. http://doi.org/10.1002/chp

Etkin, J. (2014). The Hidden Cost of Personal Quantification. *Journal of Consumer Research*, *42*(6), 967–984. http://doi.org/10.1093/jcr/ucv095

Favareau, D. (2010). Introduction: An Evolutionary History of Biosemiotics. In M. Barbieri & J. Hoffmeyer (Eds.), *Essential Readings in Biosemiotics* (Vol. 3, pp. 1–77). Dordrecht, The Netherlands: Springer. http://doi.org/10.1007/978-1-4020-9650-1

Fishbach, A., & Choi, J. (2012). When thinking about goals undermines goal pursuit. *Organizational Behavior and Human Decision Processes*, *118*(2), 99–107. http://doi.org/10.1016/j.obhdp.2012.02.003

Flanagan, O. (2011). *The Bodhisattva's Brain - Buddhism Naturalized*. London, UK: MIT Press.

Flores, M., Glusman, G., Brogaard, K., Price, N. D., & Hood, L. (2013). P4 medicine: How systems medicine will transform the healthcare sector and society. *Personalized Medicine*, *10*(6), 565–576. http://doi.org/10.2217/PME.13.57

Fogg, B. J. (2003). *Persuasive Technology: Using Computers to Change What We Think and Do*. New York, USA: Morgan Kaufmann. http://doi.org/10.1145/764008.763957

Foss, L. (1994). Putting the mind back into the body - A successor scientific model. *Theoretical Medicine*, *15*, 291–313. http://doi.org/10.1007/BF01313344

Foss, L. (2002). *The End of Modern Medicine: Biomedical Science Under A Microscope*. Albany, USA: State University of New York Press.

Foster, C., & Heeks, R. (2013). Conceptualising Inclusive Innovation: Modifying Systems of Innovation Frameworks to Understand Diffusion of New Technology to Low-Income

Consumers. *European Journal of Development Research*, *25*(3), 333–355. http://doi.org/10.1057/ejdr.2013.7

Foucault, M. (2004). The crisis of medicine or the antimedicine crisis. *Foucault Studies*, *1*, 5–19. http://doi.org/10.22439/fs.v0i1.562

Fritz, T., Huang, E. M., Murphy, G. C., & Zimmermann, T. (2014). Persuasive technology in the real world: A study of long-term use of activity sensing devices for fitness. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems (CHI '14)* (pp. 487–496). Toronto, Canada. http://doi.org/10.1145/2556288.2557383

Gao, F. (2012). Design for reflection on health behavior change. In *Proceedings of the 2012 ACM International Conference on Intelligent User Interfaces (IUI '12)* (pp. 379–382). Lisbon, Portugal. http://doi.org/10.1145/2166966.2167053

García, J. J. (2014). *Beyond the numbers - A user-centered design approach for personal reflective healthcare technology*. (Doctoral thesis, Industrial Design Engineering, Delft University of Technology). Retrieved from http://repository.tudelft.nl/islandora/object/uuid:ffbb3ab6-6d87-4444-be71-eba1bdb10817?collection=research

Gardner, C. A., Acharya, T., & Yach, D. (2007). Technological and social innovation: A unifying new paradigm for global health. *Health Affairs*, *26*(4), 1052–1061. http://doi.org/10.1377/hlthaff.26.4.1052

Garland, E. L. (2007). The Meaning of Mindfulness: A Second-Order Cybernetics of Stress, Metacognition, and Coping. *Complementary Health Practice Review*, *12*(1), 15–30. http://doi.org/10.1177/1533210107301740

Gaver, W. W., Beaver, J., & Benford, S. (2003). Ambiguity as a resource for design. In *Proceedings of Special Interest Group on Computer-Human Interaction Conference on Human Factors in Computing Systems (SIGCHI '03)* (pp. 233–240). Frt. Lauderdale, Florida, USA. http://doi.org/10.1145/642611.642653

George, G., Mcgahan, A. M., & Prabhu, J. (2012). Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda. *Journal of Management Studies*, *49*(4), 661–683. http://doi.org/10.1111/j.1467-6486.2012.01048.x

Giné, X., Karlan, D., & Zinman, J. (2008). Put Your Money Where Your Butt Is: A Commitment Savings Account for Smoking Cessation. *American Economic Journal: Applied Economics*, *2*(4), 213–35. http://doi.org/10.1257/app.2.4.213

Graffigna, G., Barello, S., Wiederhold, B. K., Bosio, A. C., & Riva, G. (2013). Positive

technology as a driver for health engagement. *Studies in Health Technology and Informatics*, *191*, 9–17. http://doi.org/10.3233/978-1-61499-282-0-9

Grouzet, F. M. E., Kasser, T., Fernández, J. M., Kim, Y., Lau, S., Ryan, R. M., … Sheldon, K. M. (2005). Goal Contents Across Cultures. *Journal of Personality and Social Psychology*, *89*(5), 800–816. http://doi.org/10.1037/0022-3514.89.5.800

Halpern, D., Bates, C., Mulgan, G., & Aldridge, S. (2004). *Personal Responsibility and Changing Behaviour : The state of knowledge and its implications for public policy*. London, UK: Prime Minister's Strategy Unit, Cabinet Office.

Hamari, J., Sarsa, H., & Koivisto, J. (2014). Does Gamification Work? — A Literature Review of Empirical Studies on Gamification. In R. H. J. Sprague (Ed.), *Proceedings of the 47th Hawaii International Conference on System Sciences (HICSS '14)* (pp. 3025–3034). Waikoloa, Hawaii: IEEE. http://doi.org/10.1109/HICSS.2014.377

Hayles, N. K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. London: The University of Chicago Press.

Hayles, N. K. (2006). *From Cyborg to Cognisphere*. *Theory, Culture & Society* (Vol. 23).

Heeks, R., Amalia, M., Kintu, R., & Shah, N. (2013). *Inclusive Innovation: Definition, Conceptualisation and Future Research Priorities* (No. 53). *Development Informatics*. Working paper for the Centre for Development Informatics Institute for Development Policy and Management: Manchester, UK. Retrieved from http://www.gdi.manchester.ac.uk/research/publications/other-working-papers/di/di-wp53/

Hick, S. F., & Furlotte, C. (2010). An Exploratory Study of Radical Mindfulness Training with Severely Economically Disadvantaged People: Findings of a Canadian Study. *Australian Social Work*, *63*(3), 281–298. http://doi.org/10.1080/0312407X.2010.496865

Holland, J. H. (2006). Studying complex adaptive systems. *Journal of Systems Science and Complexity*, *19*(1), 1–8. http://doi.org/10.1007/s11424-006-0001-z

Hood, L. (2013). Systems Biology and P4 Medicine: Past, present, and future. *Rambam Maimonides Medical Journal*, *4*(2), e0012. http://doi.org/10.5041/RMMJ.10112

Hood, L., & Auffray, C. (2013). Participatory medicine: A driving force for revolutionizing healthcare. *Genome Medicine*, *5*(12), 110. http://doi.org/10.1186/gm514

Hood, L., Balling, R., & Auffray, C. (2012). Revolutionizing medicine in the 21st century through systems approaches. *Biotechnology Journal*, *7*(8), 992–1001. http://doi.org/10.1002/biot.201100306

Hood, L., & Flores, M. (2012). A personal view on systems medicine and the emergence of

proactive P4 medicine: Predictive, preventive, personalized and participatory. *New Biotechnology*, *29*(6), 613–624. http://doi.org/10.1016/j.nbt.2012.03.004

Hood, L., Heath, J., Phelps, M., & Lin, B. (2004). Systems Biology and New Technologies Enable Predictive and Preventive Medicine. *Science*, *306*(5696), 640–643. http://doi.org/10.1126/science.1104635

Hood, L., & Price, N. D. (2014). Demystifying disease, democratizing health care. *Science Translational Medicine*, *6*(225), 225ed5. http://doi.org/10.1126/scitranslmed.3008665

Hunicke, R., LeBlanc, M., & Zubek, R. (2004). MDA: A Formal Approach to Game Design and Game Research. In *Proceedings of the Association for the Advancement of Artificial Intelligence Workshop on Challenges in Game AI (AAAI '04)* (pp. 1–4). San Jose, California, USA: AAAI Press.

Jamison, J. C. (2008). Well-Being and Neuroeconomics. *Neuroeconomics*, *24*(3), 407–418. http://doi.org/10.1017/S0266267108002046

Jones, R. H. (2015). Cybernetics, Discourse Analysis and the Entextualization of the Human. In R. H. Jones, A. Chik, & C. A. Hafner (Eds.), *Discourse and Digital Practices: Doing Discourse Analysis in the Digital Age* (pp. 28–47). London, UK: Routledge.

Judah, G., Aunger, R., Schmidt, W. P., Michie, S., Granger, S., & Curtis, V. (2009). Experimental pretesting of hand-washing interventions in a natural setting. *American Journal of Public Health*, *99*(S2), 405–411. http://doi.org/10.2105/AJPH.2009.164160

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice*, *10*(2), 144–156. http://doi.org/10.1093/clipsy.bpg016

Kabat-Zinn, J. (2013). *Full Catastrophe Living (Revised Edition)*. London, UK: Piatkus.

Kahneman, D. (2011). *Thinking, Fast and Slow*. New York, USA: Farrar, Straus and Giroux.

Kahneman, D., & Thaler, R. H. (2006). Anomalies: Utility Maximization and Experienced Utility. *Journal of Economic Perspectives*, *20*(1), 221–234. http://doi.org/10.1257/089533006776526076

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, *47*(2), 263–292. http://doi.org/10.2307/1914185

Kamenica, E. (2012). Behavioural economics and Psychology of Incentives. *Annual Review of Economics*, *4*, 427–452. http://doi.org/10.1146/annurev-economics-080511-110909

Kapeleris, J. (2012, November). The Difference Between Knowledge and Wisdom (Web log). Retrieved June 26, 2016, from http://johnkapeleris.com/blog/?p=1752

Kasser, T., & Ryan, R. M. (1996). Further Examining the American Dream : Differential

Correlates of Intrinsic and Extrinsic Goals. *Personality and Social Psychology Bulletin*, *22*(3), 280–287. http://doi.org/10.1177/0146167296223006

Keizer, K., Lindenberg, S., & Steg, L. (2008). The spreading of disorder. *Science*, *322*(5908), 1681–1685. http://doi.org/10.1126/science.1161405

King, D., Greaves, F., Exeter, C., & Darzi, A. (2013). "Gamification": Influencing health behaviours with games. *Journal of the Royal Society of Medicine*, *106*(3), 76–78. http://doi.org/10.1177/0141076813480996

King, S. K. (2009). *Urban Shaman*. New York, USA: Simon and Schuster.

Kirmayer, L. J. (2015). Mindfulness in cultural context. *Transcultural Psychiatry*, *52*(4), 447–469. http://doi.org/10.1177/1363461515598949

Kriel, J. (2015). Medicine: From art to science - and beyond. In B. Brom, J. Kriel, & J. Viall (Eds.), *Mind, Medicine and Matter - Conversations 2* (pp. 160–169). Cape Town, South Africa: Creating Health Publishers.

Langer, E. (1992). Matters of Mind : Mindfulness/Mindlessness in Perspective. *Consciousness and Cognition*, *1*(3), 289–305. http://doi.org/10.1016/1053-8100(92)90066-J

Langer, E. (2000). The Construct of Mindfulness. *Journal of Social Issues*, *56*(1), 1–9. http://doi.org/10.1111/0022-4537.00148

Langer, E. (2014, March). Mindfulness in the Age of Complexity. *Harvard Business Review*, (March 2014), 68–73.

Levav, J., & Fitzsimons, G. J. (2006). When questions change behavior: The role of ease of representation. *Psychological Science*, *17*(3), 207–213. http://doi.org/10.1111/j.1467-9280.2006.01687.x

Li, I., Dey, A., & Forlizzi, J. (2010). A stage-based model of personal informatics systems. In *Proceedings of the SGCHI Conference on Human Factors in Computing Systems (CHI '10)* (pp. 557–566). Atlanta, GA, USA: SIGCHI. http://doi.org/10.1145/1753326.1753409

Li, I., Dey, A., & Forlizzi, J. (2011). Understanding my data, myself: Supporting self-reflection with Ubicomp technologies. In *Proceedings of the 13th International Conference on Ubiquitous computing (UbiComp'11)* (pp. 405–414). Beijing, China: UbiComp. http://doi.org/10.1145/2030112.2030166

Li, I., Forlizzi, J., & Dey, A. K. (2010). Know Thyself : Monitoring and Reflecting on Facets of One's Life. In *CHI EA '10 Extended Abstracts on Human Factors in Computing Systems* (pp. 4489–4492). Atlanta, Georgia, USA: SIGCHI.

http://doi.org/10.1145/1753846.1754181

Liew, A. (2013). DIKIW: Data, information, knowledge, intelligence, wisdom and their interrelationships. *Business Management Dynamics*, *2*(10), 49–62. Retrieved from https://www.researchgate.net/publication/236870996_DIKIW_Data_Information_Knowledge_Intelligence_Wisdom_and_their_Interrelationships

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. Los Angeles, California, USA: Sage Publications.

Lindley, D. (1993). *The End of Physics*. New York: Basic Books.

Luhmann, N. (1984). *Social Systems*. (J. Bednarz, Jr., & D. Baecker, Trans. 1995). Stanford, California, USA: Stanford University Press.

Lupton, D. (2013a). Quantifying the body: Monitoring and measuring health in the age of mHealth technologies. *Critical Public Health*, *23*(4), 393–403. http://doi.org/10.1080/09581596.2013.794931

Lupton, D. (2013b, December). Understanding the Human Machine. *IEEE Technology and Society Magazine*, (Winter 2014), 25–30.

Lupton, D. (2014). Self-tracking modes: Reflexive self-monitoring and data practices. In *Proceedings of the "Imminent Citizenships: Personhood and Identity Politics in the Informatic Age" Workshop*. Canberra, Australia. http://doi.org/10.2139/ssrn.2483549

Lupton, D. (2016). You are your data: Self-tracking practices and concepts of data. In S. Selke (Ed.), *Lifelogging: Digital self-tracking and lifelogging - between disruptive technology and cultural transformation* (pp. 61–79). London, UK: Springer.

Luz, M. T., & De Camargo, K. R. J. (1997). A Comparative Study of Medical Rationalities. *Curare Journal of Ethnomedicine*, *12*, 1–22.

Mann, T., & Ward, A. (2007). Attention, Self-Control, and Health Behaviors. *Current Directions in Psychological Science*, *16*(5), 280–283. http://doi.org/10.1111/j.1467-8721.2007.00520.x

Marcengo, A., & Rapp, A. (2013). Visualization of Human Behavior Data. In M. L. Huang & W. Huang (Eds.), *Innovative Approaches of Data Visualization and Visual Analytics* (pp. 236–265). Hershey, Pennsylvania, USA: IGI Global. http://doi.org/10.4018/978-1-4666-4309-3.ch012

Marks, J. T. (2012). *Kolb Interupted*. (Doctoral thesis, Department of Engineering, University of Cape Town, South Africa). Retrieved from https://open.uct.ac.za/handle/11427/6884

Marton, F. (1986). Phenomenography—A Research Approach to Investigating Different

Understandings of Reality. *Journal of Thought*, *21*(3), 28–49.

Marton, F. (1994). The Idea of Phenomenography. In R. Ballantyne & C. Bruce (Eds.), *Proceedings of the Conference on Phenomenology - Philosophy & Practice* (p. 7). Brisbane, Australia: Queensland University of Technology. Retrieved from http://eprints.qut.edu.au/53908/1/53908.pdf#page=19

Marton, F., & Booth, S. (1997). *Learning and Awareness*. New York, NY, USA: Routledge.

Marton, F., & Pang, M. F. (1999). Two faces of variation. In *Proceedings of the 8th European Conference for Learning and Instruction*. Goteborg, Sweden. http://doi.org/10.1080/00313830308612

Marton, F., & Svensson, L. (1979). Conceptions of research in student learning. *Higher Education Research & Development*, *8*, 471–486. http://doi.org/10.1007/BF01680537

Maturana, H. R. (1981). The Organization of the Living: A Theory of the Living Organization. In K. Krippendorff & M. Zeleny (Eds.), *Cybernetics Forum: A Special Issue Devoted To Autopoiesis* (Vol. 10, pp. 14–23). Lewisburg, PA, USA: American Society for Cybernetics.

Maturana, H. R., & Varela, F. J. (1980). Autopoesis and Cognition. The Realization of the Living. Dordrecht, The Netherlands: D. Reidel.

Maturana, H. R., & Varela, F. J. (1987). *The Tree of Knowledge - The Biological Roots of Human Understanding*. Boulder, CO, USA: Shambala.

Maxwell, J. C. (2000). *Failing forward*. Mumbai, India: Magna Publishing.

Mazaza, S. (2015). The Biomedical Model and the Future of Healthcare in South Aftrica. In B. Brom, J. Kriel, & J. Viall (Eds.), *Mind Matter and Medicine: Conversations 2* (pp. 123–129). Cape Town, South Africa: Creating Health Publishers.

McCurdy, K. (2015). Visual storytelling in healthcare: Why we should help patients visualize their health. *Information Visualization*, *July 2015*, 1–6. http://doi.org/10.1177/1473871615592255

McHattie, L. S., Cumming, G., & French, T. (2014). Transforming patient experience: Health web science meets medicine 2.0. *Journal of Medical Internet Research*, *16*(3), 1–9. http://doi.org/10.2196/med20.3128

McLuhan, M. (1964). *Understanding Media: The Extensions of Man*. Cambridge, Massachusetts, USA: MIT Press.

Meschtscherjakov, A., Boris, D. R., Fuchsberger, V., Murer, M., & Tscheligi, M. (Eds.). (2016). Persuasive Technology. In *Proceedings of 11th International Conference, Persuasive 2016, Lecture Notes in Computer Science 9638*. Salzburg, Austria: Springer.

Miller, D. T., & Ross, M. (1975). Self-serving biases in the attribution of causality: Fact or fiction? *Psychological Bulletin*, *82*(2), 213–225. http://doi.org/10.1037/h0076486

Moore, B., Kleek, M. Van, Karger, D. R., & Schraefel, M. (2010). Assisted Self Reflection: Combining Lifetracking, Sensemaking & Personal Information Management. In *Proceedings of the 28th International ACM Conference on Human Factors in Computing Systems - Know Thyself: Monitoring and Reflecting on Facets of One's Life (CHI '10)*. Atlanta, Georgia, USA: SIGCHI.

Mulgan, G. (2006). The Process of Social Innovation. *MIT Innovations*, *1*(2), 145–162. http://doi.org/10.1162/itgg.2006.1.2.145

Munson, S. (2012a). Mindfulness, Reflection, and Persuasion in Personal Informatics. In *Proceedings of Personal Informatics Workshop (CHI '12)*. Austin, Texas,USA: SIGCHI.

Munson, S. (2012b, March). Personal Informatics In Practice: Reflection and Persuasion in Personal Informatics. *Quantified Self*. Retrieved from http://quantifiedself.com/sean-munson/

Munson, S., & Consolvo, S. (2012). Exploring Goal-setting, Rewards, Self-monitoring, and Sharing to Motivate Physical Activity. In *Proceedings of International Conference on Pervasive Computing Technologies for Healthcare (CHI 2012)* (pp. 25–32). San Diego, CA, USA. http://doi.org/10.4108/icst.pervasivehealth.2012.248691

Nafus, Dawn; Sherman, J. (2014). This One Does Not Go Up to 11 : The Quantified Self Movement as an Alternative Big Data Practice. *International Journal of Communication*, *8*, 1784–1794.

Niedderer, K. (2013). Mindful Design as a Driver for Social Behaviour Change. In *Consilence and Innovation in Design - Proceedings of the 5th International Congress of International Association of Societies of Design Research* (pp. 4562–4572). Tokyo, Japan: IASDR.

Nielsen, K., & Munir, F. (2009). How do transformational leaders influence followers' affective well-being? Exploring the mediating role of self-efficacy. *Work & Stress*, *23*(4), 313–329. http://doi.org/10.1080/02678370903385106

Norris, N., & Walker, R. (2007). Naturalistic Inquiry. In B. Somekh & C. Lewin (Eds.), *Research Methods in the Social Sciences* (pp. 131–137). London, UK: Sage Publications.

Oh, J., & Lee, U. (2015). Exploring UX issues in Quantified Self technologies. In *2015 Eighth International Conference on Mobile Computing and Ubiquitous Networking*

(ICMU) (pp. 53–59). Hakodate City, Hokkaido, Japan: IEEE. http://doi.org/10.1109/ICMU.2015.7061028

Pagnini, F., & Philips, D. (2015). Being mindful about mindfulness. *The Lancet Psychiatry*, *2*(4), 288–289. http://doi.org/10.1016/S2215-0366(15)00041-3

Paharia, R. (2010). Driving User Behavior with Game Dynamics and Behavioural economics. *Presented at Stanford HCI Seminar February 2010*. Stanford, California, USA: Stanford University.

Paina, L., & Peters, D. H. (2012). Understanding pathways for scaling up health services through the lens of complex adaptive systems. *Health Policy and Planning*, *27*(5), 365–373. http://doi.org/10.1093/heapol/czr054

Patel, D., Lambert, E. V, da Silva, R., Greyling, M., Kolbe-Alexander, T., Noach, A., … Gaziano, T. (2011). Participation in fitness-related activities of an incentive-based health promotion program and hospital costs: a retrospective longitudinal study. *American Journal of Health Promotion*, *25*(5), 341–8. http://doi.org/10.4278/ajhp

Plsek, P. E., & Greenhalgh, T. (2001). Complexity science: The challenge of complexity in health care. *British Medical Journal*, *323*(7313), 625–8. http://doi.org/10.1136/bmj.323.7313.625

Riva, G., Baños, R. M., Botella, C., Wiederhold, B. K., & Gaggioli, A. (2012). Positive Technology: Using Interactive Technologies to Promote Positive Functioning. *Cyberpsychology, Behavior, and Social Networking*, *15*(2), 69–77. http://doi.org/10.1089/cyber.2011.0139

Rogers, E. M. (1962). *Diffusion of Innovations*. New York, USA: Free Press of Glencoe.

Rogers, E. M., Medina, U. E., Rivera, M. A., & Wiley, C. J. (2005). Complex adaptative systems and the diffusion of innovations. *The Innovation Journal: The Public Sector Innovation Journal*, *10*(3), 1–26.

Rose, N. (2007). Beyond medicalisation. *The Lancet*, *369*(9562), 700–702. http://doi.org/10.1016/S0140-6736(07)60319-5

Rosnay, J. De. (1979). *The Macroscope: A Systemic Approach to Complexity*. Retrieved from http://scholar.google.nl.ezproxy.elib10.ub.unimaas.nl/scholar?hl=nl&q=macroscope+joel+de+rosnay&btnG=Zoeken&lr=&as_ylo=&as_vis=0#3

Rothenberg, K., & Foss, L. (1987). *The Second Medical Revolution: From Biomedicine to Infomedicine*. Boston, Mass, USA: Shambhala.

Ryan, R. M., Huta, V., & Deci, E. L. (2008). Living well: A self-determination theory perspective on eudaimonia. *Journal of Happiness Studies*, *9*, 139–170.

http://doi.org/10.1007/s10902-006-9023-4

Säljö, R. (1979). Learning about Learning. *Higher Education*, *8*, 443–451. http://doi.org/10.1007/BF01680533

Sandbergh, J. (1997). Are Phenomenographic Results Reliable? *Higher Education Research & Development*, *16*(2), 203–212. http://doi.org/10.1080/0729436970160207

Schiavone, G., De Anna, G., Mameli, M., Rebba, V., & Boniolo, G. (2014). Libertarian paternalism and health care policy : A deliberative proposal. *Medicine, Health Care and Philosophy*, *17*(1), 103–113. http://doi.org/10.1007/s11019-013-9502-4

Schmuck, P., Kasser, T. I. M., & Ryan, R. M. (2000). Intrinsic and extrinsic goals: their structure and relationship to well-being in german and u.s. college students. *Social Indicators Research*, *50*(2), 225–241. http://doi.org/10.1023/A:1007084005278

Schüll, N. D. (2015). Data for Life: Wearable Technology and the Design of Self-Care. *Biosocieties (Forthcoming)*, 1–23. http://doi.org/10.1057/biosoc.2015.47

Schumpeter, J. A. (1934). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. New Brunswick, USA and London, UK: Transaction Publishers.

Schwartz, G. E. (1982). Testing the biopsychosocial model: the ultimate challenge facing behavioral medicine? *Journal of Consulting and Clinical Psychology*, *50*(6), 1040–1053. http://doi.org/10.1037/0022-006X.50.6.1040

Schwartz, M. A., & Wiggins, O. P. (1986). Systems Contributions and the Structuring of Meaning : Medicine to a Biopsychosocial. *American Journal of Psychiatry*, *143*(10), 1213–1221. http://doi.org/10.1176/ajp.143.10.1213

Scott, B., Curtis, V., Rabie, T., & Garbrah-Aidoo, N. (2007). Health in our hands, but not in our heads: Understanding hygiene motivation in Ghana. *Health Policy and Planning*, *22*(4), 225–233. http://doi.org/10.1093/heapol/czm016

Sharov, A. A. (2010). Functional information: Towards synthesis of biosemiotics and cybernetics. *Entropy*, *12*(5), 1050–1070. http://doi.org/10.3390/e12051050

Siegel, D. J. (2001). Toward an Interpersonal Neurobiology of the Developing Mind : Attachment Relationships , " Mindsight ," and Neural Integration. *Infant Mental Health Journal*, *22*(1–2), 67–94.

Siegel, D. J. (2006). An Interpersonal Neurobiology Approach to Psychotherapy: Awareness, Mirror Neurons, and Neural Plasticity in the Development of Well-Being. *Psychiatric Annals*, *36*, 1–18.

Siegel, D. J. (2007a). Mindfulness training and neural integration: Differentiation of distinct

streams of awareness and the cultivation of well-being. *Social Cognitive and Affective Neuroscience*, *2*(2007), 259–263. http://doi.org/10.1093/scan/nsm034

Siegel, D. J. (2007b, November). Mindfulness , Psychotherapy and the Brain. Retrieved from http://www.ithou.org/node/2730

Siegel, D. J. (2009a). Mindful Awareness, Mindsight, and Neural Integration. *The Humanistic Psychologist*, *37*(2), 137–158.

Siegel, D. J. (2009b, October). The Power of Mindsight. Retrieved from https://www.youtube.com/watch?v=Nu7wEr8AnHw

Siegel, D. J. (2010). *Mindsight: The New Science of Personal Transformation* (1st ed.). New York, NY, USA: Bantam.

Siegel, R. D., Germer, C. K., & Olendzki, A. (2009). Mindfulness: What is it? where did it come from? In F. Didonna (Ed.), *Clinical Handbook of Mindfulness* (pp. 17–35). New York, NY, USA: Springer. http://doi.org/10.1007/978-0-387-09593-6_2

Smarr, L. (2012). Quantifying your body: A how-to guide from a systems biology perspective. *Biotechnology Journal*, *7*(8), 980–991. http://doi.org/10.1002/biot.201100495

Sobradillo, P., Pozo, F., & Agusti, L. (2011). P4 Medicine: The Future Around the Corner. *Archivos de Bronconeumologia*, *47*(1), 35–40. http://doi.org/10.1016/j.arbres.2010.09.009

Stibe, A., & Cugelman, B. (2016). Persuasive Backfiring: When Behavior Change Interventions Trigger Unintended Negative Outcomes. In A. Meschtscherjakov et. al (Ed.), *Persuasive Technology - 11th International Conference, Persuasive 2016, Lecture Notes in Computer Science 9638* (pp. 65–77). Salzburg, Austria: Springer. http://doi.org/10.1007/978-3-319-31510-2_6

Strum, R., An, R., Segal, D., & Patel, D. (2013). A Cash-Back Rebate Program for Healthy Food Purchases in South Africa Results. *American Journal of Preventive Medicine*, *44*(6), 567–572. http://doi.org/10.1016/j.amepre.2013.02.011

Sturmberg, J. P., & Martin, C. M. (2014). Systems and Complexity Thinking in the General Practice Literature: An Integrative, Historical Narrative Review. *Annals Of Family Medicine*, *12*(1), 66–74. http://doi.org/10.1370/afm.1593

Svensson, L. (1997). Theoretical Foundations of Phenomenography. *Higher Education Research & Development*, *16*(2), 159–171. http://doi.org/10.1080/0729436970160204

Swan, M. (2009). Emerging patient-driven health care models: An examination of health social networks, consumer personalized medicine and quantified self-tracking.

International Journal of Environmental Research and Public Health, *6*(2), 492–525. http://doi.org/10.3390/ijerph6020492

Swan, M. (2012a). Medicine Health 2050 : The Realization of Personalized Medicine through Crowdsourcing, the Quantified Self , and the Participatory Biocitizen. *Journal of Personalized Medicine*, *2*(3), 93–118. http://doi.org/10.3390/jpm2030093

Swan, M. (2012b). Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0. *Journal of Sensor and Actuator Networks*, *1*(3), 217–253. http://doi.org/10.3390/jsan1030217

Swan, M. (2013). The Quantified Self: Fundamental Disruption in Big Data Science and Biological Discovery. *Big Data*, *1*(2), 85–99. http://doi.org/10.1089/big.2012.0002

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth and happiness*. New Haven, CT, USA: Yale University Press.

Tiago, M. T. B., Tiago, F., Amaral, F. E. B., & Silva, S. (2016). Healthy 3.0: Healthcare Digital Dimensions. In A. Dwivedi (Ed.), *Reshaping Medical Practice and Care with Health Information Systems* (p. 287–313 (36)). Hershey, PA, USA: IGI Global.

Trapnell, P. D., & Campbell, J. D. (1999). Private self-consciousness and the five-factor model of personality: Distinguishing rumination from reflection. *Journal of Personality and Social Psychology*, *76*(2), 284 – 304. http://doi.org/10.1037//0022-3514.76.2.284

Tversky, A., & Kahneman, D. (1974). Judgement under Uncertainty: Heuristics and Biases. *Science*, *185*(4157), 1124–1131. http://doi.org/10.1126/science.185.4157.1124

Vacca, R., & Hoadley, C. (2016). Self-Reflecting and Mindfulness: Cultivating Curiosity and Decentering Situated in Everyday Life. In A. Meschtscherjakov, D. R. Boris, V. Fuchsberger, M. Murer, & M. Tscheligi (Eds.), *Persuasive Technology - 11th International Conference, Persuasive 2016, Lecture Notes in Computer Science 9638* (pp. 87–98). Salzburg, Austria: Springer.

Van Berkel, N., Luo, C., Ferreira, D., Goncalves, J., & Kostakos, V. (2015). The Curse of Quantified-self: An Endless Quest for Answers. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing / International Symposium on Wearable Computers (UbiComp/ISWC'15)* (pp. 973–978). Osaka, Japan: UbiComp/ISWC. http://doi.org/10.1145/2800835.2800946

van Dijk, E. T., Beute, F., & Westerink, Joyce H.D.M; Ijsselsteijn, W. A. (2015). Unintended effects of self-tracking. In *Human Factors in Computing Systems - Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. Seoul, Korea: ACM.

Varela, F. J., Thompson, E., & Rosch, E. (1992). *The Embodied Mind Cognitive Science and Human Expierience*. Cambridge, Mass, USA: MIT Press.

Von Bertalanffy, L. (1950). The theory of open systems in physics and biology. *Science*, *111*(2872), 23–29. http://doi.org/10.1126/science.111.2872.23

Watkins, E. R. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin*, *134*(2), 163–206. http://doi.org/10.1037/0033-2909.134.2.163

Weston, A. D., & Hood, L. (2004). Systems Biology , Proteomics , and the Future of Health Care : Toward Predictive , Preventative , and Personalized Medicine Introduction : Paradigm Changes in Health Care. *Journal of Proteome Research*, *3*(2), 179–96. http://doi.org/10.1021/pr0499693

Wiederhold, B. K., & Riva, G. (2012). Positive Technology Supports Shift to Preventive, Integrative Health. *Cyberpsychology, Behavior, and Social Networking*, *15*(2), 67–68. http://doi.org/10.1089/cyber.2011.1533

Wiener, N. (1954). *The Human Use of Human Beings: Cybernetics and society*. London, UK: Eyre and Spottiswoode.

Wiener, N. (1961). *Cybernetics or control and communication in the animal and the machine (Second Edition)* (Vol. 46). Cambridge, Mass, USA: MIT Press.

Williams, B. R., Bezner, J., Chesbro, S. B., & Leavitt, R. (2005). The Relationship Between Achievement of Walking Goals and Exercise Self-Efficacy in Postmenopausal African American Women. *Journal of Geriatric Physical Therapy*, *24*(4), 305–314. http://doi.org/10.1097/TGR.0b013e31818ccfed

Williams, J. M. G., & Kabat-Zinn, J. (2011). Mindfulness: Diverse perspectives on its meaning, origins, and multiple applications at the intersection of science and dharma. *Contemporary Buddhism*, *12*(1), 1–18. http://doi.org/10.1080/14639947.2011.564811

Wolf, G. (2010, June). The Quantified Self [Video file]. *TED*. Retrieved from https://www.ted.com/talks/gary_wolf_the_quantified_self

Wolf, G., & Kelly, K. (2009, October). Introducing The Quantified Self Advisory Board. *Quantified Self*. Retrieved from http://quantifiedself.com/2009/10/introducing-the-quantified-sel/

Wryobeck, J., & Chen, Y. (2003). Using Priming Techniques to Facilitate Health Behaviours. *Clinical Psychologist*, *7*(2), 105–108. http://doi.org/10.1080/13284200410001707553

Yates, C., Partridge, H., & Bruce, C. (2012). Exploring information experiences through phenomenography, *36*(112), 96–119.

Zarnekow, R., Matallaoui, A., & Hanner, N. (2017). Introduction to Gamification: Foundation and Underlying Theories. In S. Stieglitz, C. Lattemann, S. Robra-Bissantz, R. Zarnekow, & T. Brockmann (Eds.), *Gamification - Using Game Elements in Serious Contexts* (pp. 3–18). Cham, Switzerland: Springer. http://doi.org/10.1007/978-3-319-45557-0_1

Zeleny, M. (1981). Self-Organization of Living Systems: A Formal Model of Autopoiesis. In K. Krippendorff & M. Zeleny (Eds.), *Cybernetics Forum: A Special Issue Devoted To Autopoiesis* (Vol. 10, pp. 24–40). Lewisburg, PA, USA: American Society for Cybernetics.

Zeleny, M. (2006). Knowledge-information autopoietic cycle: Towards the wisdom systems. *International Journal of Management and Decision Making*, *7*(1), 3–18. http://doi.org/10.1504/IJMDM.2006.008168

APPENDIX A: BEHAVIOURAL ECONOMICS

To enable identification of how common BE principles are used and applied in the design of PI systems for behaviour change and the promotion of wellbeing, the following section will provide a deeper exploration of known principles, drawing on work of Ariely (2009), Amir and Ariely (2008), Blumenthal-Barby and Burroughs (2012), Dolan, et al. (2012), Halpern, et al. (2004) Kahneman and Tversky (1979), Kahneman (2012), and Thaler and Sunstein (2008), amongst others. Dolan, et al. (2012) present the acronym MINDSPACE to encapsulate a set of BE principles to inform more effective design of policies and systems. These principles, which predominantly tap into automatic System 1 thinking are defined in short in the table below.

Table 3: Behavioural science in an easy format: a summary of the main influences described in the MINDSPACE report (Cabinet Office and Institute For Government, 2010)

Messenger	We are heavily influenced by who communicates information
Incentives	Our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses
Norm	We are strongly influenced by what others do
Defaults	We 'go with the flow' of pre-set options
Salience	Our attention is drawn to what is novel and seems relevant to us
Priming	Our acts are often influenced by subconscious cues
Affect	Our emotional associations can powerfully shape our actions
Commitment	We seek to be consistent with our public promises, and reciprocate acts
Ego	We act in ways that make us feel better about ourselves

The following section will explore these concepts in greater depth and offer examples of application in practice.

1. Messenger

We are heavily influenced by who communicates information:

"The medium is the message. It is the medium that shapes and controls the scale and form of human association and action" (McLuhan, 1964). The perceived credibility of information thus depends largely on the subconscious perception of the source or medium of that information – the 'messenger'. As such, people are more likely to act on information when

the messenger is authoritative, even if it can cause harm or stress. Authority can further be tactically fabricated by having experts deliver a message. Such messages can have more powerful and extensive impact than what rational analysis might suggest, and can motivate behaviour that would not take place without the authority prompt.

Furthermore, feeling for the messenger affects the impact: for example, when the messenger has similar characteristics to the audience, the message is better received; advice given by a disliked source may be discarded. Such feelings also have the ability to override traditional authoritative cues, i.e. someone who has developed a dislike, or distrust, of institutional interventions may be less likely to listen to messages that they perceive to come from said institutions. Members of lower socio-economic groups are more susceptible to influence of the messenger being similar to them, for example age, gender, ethnicity, social class/status, culture, profession, etc. People further use more reasoned means to assess how convincing a messenger is, by for example, considering issues such as whether there is a consensus across society and whether there is a consistency across occasions (Dolan, et al., 2012).

2. Incentives

Our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses.

External incentives are often used to motivate desired behaviours. Among other novel uses, within this context, incentives or rewards are used primarily to motivate people to lose weight, take medications, exercise, and stop smoking. These incentives could be financial (for example, bonuses, cash backs, discounts, etc.) or other forms of physical reward (for example. badges, trophies, treats, etc.). Furthermore, virtual incentives, such as digital badges, trophies and statuses are also awarded for reaching goals within gamified virtual contexts, using various measurement matrices.

The impact of incentives is clearly related to factors such as the sort, scale and timing. BE suggests further influences, which can allow us to design more effective schemes. Four key related insights from BE are:

- *Reference points matter*

  Economic theory accepts that we care only about final outcomes; however, evidence

shows that the value of something depends on how it appears relative to from where it is observed (Kahneman & Tversky, 2000).

- *Losses loom larger than gains (Loss aversion)*
  Effected by these reference points, people have a stronger aversion to losses than affinity for gains of equal magnitude. Therefore, incentives yield better results if they are framed relative to loss (Kahneman & Tversky, 1979).
- *We overweigh small probabilities*
  People place more weight on small probabilities than what is theoretically rational, i.e. people 'overweight' changes in probability moving from certainty to uncertainty more than midway. Specifically, people are prone to overestimate the probability of unlikely events that are easy to imagine (Kahneman & Tversky, 1979). Communications and media campaigns thus create greater awareness and more biased assumptions that certain risks are more pronounced by presenting examples of real cases of deadly results (e.g. smoking causing cancer deaths). These intense, frequently encountered cases will increase perceptions of liability, because human judgment is constructed by referring to examples drawn from the environment or memory (Dolan, et al., 2012).
- *We inconsistently live for today at the expense of tomorrow (Hyperbolic discounting)*
  Hyperbolic discounting or future discounting refers to the tendency forego future wellbeing for immediate gratification (Blumenthal-Barby & Burroughs, 2012; Dow Schull & Zaloom, 2011). Furthermore, people usually prefer smaller, more immediate payoffs, to superior, more distant ones. R10 today may be preferred to R12 tomorrow. But R12 in eight days may be preferred to R10 in a week's time. This implies that we have a very high discount rate for now compared to later, but a lower discount rate for later compared to later still. Hyperbolic discounting leads people to discount the future very heavily when sacrifices are required in the present – for example, to ensure improved health outcomes in the future.

Datta and Mullainathan (2014) maintain that even a small monetary or material incentive has the power to induce a change with large consequences – behavioural economists have found that such "micro-incentives" affect how people behave in ways that have a major impact on their wellbeing. They contend that the size of an incentive only needs to be as big as the barrier causing the problem.

3. Norms

We are strongly influenced by what others do.

Behavioural rules or expectations within a society or group to which individuals in a social group try to conform are referred to as social and cultural norms. It is also described as a standard, customary, or ideal form of behaviour. Norms affect behaviour as people are influenced by what others do and use perceived norms as a standard against which to compare their own behaviour. Social norms stimulate positive feedback loops in behaviours, where the more widely that a norm is followed by members of a social group, the more people want to adhere to it. Four main lessons based on norms are emphasised by Dolan, et al. (2012):

- If the norm is desirable, let people know about it.
- Relate the norm to the target audience as much as possible.
- Norms may need reinforcing.
- Descriptive norms can backfire when people hear that others are behaving worse than them, causing a 'boomerang' effect.

In line with wider literature on the power of subconscious influence, there is considerable evidence that 'declarative' norms have considerable power. In other words, we are influenced more by what we perceive or believe others are doing rather than norms that refer to what we 'ought' to be doing. For example, norms about what works for others offer influential signals. Furthermore, following the behaviour of others may also produce positive reinforcement through the feeling of being a part of something without much effort or real interaction (Dolan, et al., 2012).

4. Defaults

We 'go with the flow' of pre-set options.

Another way in which behavioural economics principles are being used to change health behaviours and decisions is through the use of defaults. The insight that people tend to go with the flow of pre-set options, make using defaults options that promote health and wellbeing and save money, requiring those who want to go against the grain to 'opt out' a viable tactic (Blumenthal-Barby & Burroughs, 2012).

Dolan, et al. (2012) agree, stating that we tend to assume that people make active decisions: faced with a selection of options, they will actively choose the one they prefer. However, behaviour economists have established that people often reflexively accept an option that requires them to do nothing. This places disproportionately significance on designated default options. Similarly, seemingly insignificant steps and choices (for example, to fill in a form or the requirement to submit one that has already been filled in) can radically reduce the number of people who partake in a programme. As such, participation, submission and use increases significantly when defaults are set to encourage participation, or when a program is designed to minimise the number of things people have to do to take benefit from it.

Defaults are also related to other BE factors such as hyperbolic discounting, loss aversion, presumed 'suggestions' that imply a recommended action. Defaults provide 'anchors', creating mental reference points and perceived norms (Ariely, 2009).

5. Salience

Our attention is drawn to what is novel and seems relevant to us, and energy flows where attention goes.

In other words, our behaviour is greatly influenced by that which draws our attention (Dolan, et al., 2012; Kahneman & Thaler, 2006; King, 2009). As a result of the bombardment of stimuli in modern living, people tend to unconsciously filter out much information as a coping strategy. People are more likely to register salient messaging, i.e. messaging that is unusual, accessible and simple (on a flashing banner, positioned at a pay point, or conveyed by a sharp or punchy slogan). Because our attention is more easily captured by things that we can effortlessly understand or 'encode' in our minds, simplicity and relatability is important. Behaviour change studies have demonstrated that information is much more likely taken into account if it is salient (Dolan, et al., 2012).

For example, participants in a study were more likely to respond to health-promoting messages and showed considerably more self-control in the domains of eating, smoking, and aggression when cues suggesting self-control or self-restraint were salient and attention-grabbing (Mann & Ward, 2007).

Salient messaging further has the ability to subconsciously anchor the user's thinking, creating a mental reference point, in a similar way that defaults do. The so-called anchor exerts a sort of 'magnetic attraction', creating a mental benchmark or starting point for conceptualising or estimating an unknown quantity or outcome (Tversky & Kahneman, 1974).

6. Priming

Our acts are often influenced by subconscious cues.

Priming by means of exposure to certain situational cues may influence or alter people's subsequent behaviour. In other words, people behave differently after being primed by particular visuals, words, objects or sensations. This could refer to activating knowledge in memory, making this knowledge more accessible and therefore more influential in the assimilation of new stimuli (Dolan et al., 2012).

For example, a study by Wryobeck and Chen (2003) found that asking participants to make a sentence out of a list of fitness related words such as fit, lean, active, athletic made them significantly more likely to use the stairs, instead of the elevator. Priming through words can also be achieved by simply enquiring what people intend to do, because such questions facilitate recall and mental representation of new behaviours (Dolan, et al., 2012). Asking participants of a study to indicate the likelihood of flossing their teeth in the coming week significantly increased the frequency of this behaviour over that period (Levav & Fitzsimons, 2006). Asking whether people planned to consume fatty foods in the next week made them less likely to do so (Thaler & Sunstein, 2008). Tactically placing certain visuals or objects in a person's environment can influence behaviour. For example, situational visual cues like running shoes and runner's magazines may prime a healthy lifestyle in people (Wryobeck & Chen, 2003). In these ways, priming can stimulate intentions or reinforce existing intentions to act or behave in a certain way.

It has further been shown in six controlled field experiments that littering or graffiti in an environment encourage further destructive behaviour like stealing. When people perceive an apparent status quo, in this case that others violated a certain social norm or rule, they are

more likely to follow or expand on the status quo and violate further norms or rules (Keizer, Lindenberg, & Steg, 2008).

Another way in which people can be primed to make healthier choices is through reminders. Blumenthal-Barby & Burroughs (2012) present the iPhone application, Nudgersize, which reminds its users to get their daily exercise, as an example. Perhaps the most unusual example of visual situational cue to nudge behaviour is the fly etched into the urinals in the Amsterdam Airport, which draws men's attention by providing a novel target of sorts, subtly priming them to aim, reducing spillage by 80% (Thaler & Sunstein, 2008).

When priming is linked to System 1 thinking, or attention, it is evident that many of the daily choices we make are done so without us having insight into what influences these choices. The focus of our awareness can often be unconscious too, as we observe things without noticing it. For example, we might suddenly crave something unhealthy like pizza, not recognising that our craving has been triggered by a billboard ad for a pizza chain (Dolan, et al., 2012).

7. Affect

Our emotional associations can powerfully shape our actions.

Affect, or act of experiencing emotion (Dolan, et al., 2012), is a powerful influence in decision-making and closely linked - often coupled (Blumenthal-Barby & Burroughs, 2012) - with the concept of salience as outlined above.

Words, images and events can trigger rapid and automatic emotional behavioural reactions with emotional or irrational - as opposed to cognitive or rational - evaluations as the basis of decisions and action (Ariely, 2009; Kahneman, 2011; Thaler & Sunstein, 2008). All perceptions contain some emotion. Thus contextual use of words, images, film and objects can cause emotional, rather than planned, responses that can drive important decisions. Key to success is that the things that are made salient achieve greater effect and motivate people emotionally (for example, fear of death or disability) or are things that the person cares about (for example, money, avoiding losses generally) (Blumenthal-Barby & Burroughs, 2012).

Provoking emotion has been shown to change health related behaviours too. For example, two studies of campaigns that encourage soap use (Judah, et al., 2009; Scott, Curtis, Rabie & Garbrah-Aidoo, 2007) showed that advertising that focused on provoking reactions of disgust and fear of contamination – as opposed to advertising that focused on the simple benefits of soap use – led to an up to 41% increase in the reported use of soap for hand washing, specifically before eating and after using the toilet.

Furthermore, salience and affect have also been used to nudge physicians toward better health outcomes. For example, patient photographs attached to x-rays resulted in specialists providing longer, more detailed reports and feeling more compassion for their patients (Blumenthal-Barby & Burroughs, 2012).

An array of studies discussed by Dolan, et al. (2012) demonstrate how incidental visceral states and emotions (for example, sadness, hunger and disgust) can influence behaviour and consumption decisions, over both long and short term and also decisions under uncertainty, even when real money is at stake. It is thus argued that these factors and contexts can induce affect, acting as anchors which then impact upon aspects such as the prices used in the market place, and can ultimately have profound effects, on the economy, for example (Ariely & Simonson, 2003).

8. Commitment

We seek to be consistent with our public promises, and reciprocate acts.

People seek to be consistent with public promises and commitments, and act in ways to make feel better about ourselves (Blumenthal-Barby & Burroughs, 2012). However, people also tend to procrastinate and postpone decisions that are likely to be in their long-term interests. Many people are aware of these willpower limitations (for example, tendencies to overspend, overeat or continue smoking) and use commitment devices to follow through with long-term goals (Dolan, et al., 2012), such as web services and apps that allow users to commit themselves to achieving certain goals, for example, losing weight, exercising, quitting smoking or even learning a new hobby.

One such example, discussed by Blumenthal-Barby & Burroughs (2012), is stickk.com, goal-setting platform created by behavioral economists at Yale University, developed based on studies that show the effectiveness of commitments on behaviour. The platform enables users to enter into binding contracts in which they can define a goal, the stakes, and an external moderator or referee to validate their reports. Users who attach stakes to their goal can do so by self-imposing a financial incentive by entering their credit card information, and if they fail to achieve their goal, they are charged for the amount on which they agreed. Users bear all risk of any inability to achieve commitment and the contract can only be cancelled with a medical justification from a doctor. The statistics from stickk.com are remarkable, with the sum of $26 048 333 dollars on the line, 316 757 commitments created, 812 325 workouts completed which might not have happened and 15 863 400 cigarettes not smoked which may otherwise have been (stickk.com, accessed July 15, 2016).

Pre-commitment in itself might be a rational reflective action, even if the subsequent effects of commitment devices operate mainly on the automatic system, for example, System 1 fear of being judged, reputation damage and/or excluded from a group as a result of failure to stick to one's publicly made pledges or commitments (Dolan, et al., 2012).

These principles have been applied to help people quit smoking (Giné, Karlan, & Zinman, 2008). Smokers were offered a savings account in which funds were deposited. After six months, they were tested for nicotine and if they passed with no presence of nicotine, they were refunded. If they smoked, their money was forfeited. Random surprise tests at 12 months showed an effect on sustained smoking cessation: the monetary commitment increased the likelihood of stopping smoking by 30%.

Yet, commitment strategies do not necessarily require tangible penalties or rewards to be effective. Dolan (2012) contends that even the very act of writing or pledging a commitment can increase the likelihood of it being fulfilled. Pledging a commitment to achieve a symbolic goal (for example, taking 10 000 steps a day using an activity tracker to increase physical exercise) appears to significantly increase success. Numerous studies have demonstrated that commitment to specified exercise goals (specifically daily step counts) significantly increases the likelihood of increased activity and achievement of exercise goals when compared to control groups who were simply given a walking programme without any agreement or active

tracking by means of a pedometer (Smith-Spangler, et al., 2007; Williams, Bezner, Chesbro & Leavitt, 2005).

A concluding aspect of commitment is the principle of reciprocity. People have a strong instinct to reciprocate, which is linked to a desire for fairness that can also lead to irrational. We can see the desire for reciprocity strongly in the attitude of "I'll commit to it if you do". And in accepting a gift or token, which subconsciously acts as a powerful commitment to in some way return the gesture at some point, which is why free samples and other forms of added value are often effective marketing tools to build affinity and loyalty (Dolan, et al., 2012).

9. Ego

We act in ways that make us feel better about ourselves.

People tend to put energy into behaving in ways that make a positive impression to support a consistent and favourable self-image, attributing positive outcomes to themselves and blaming others or situations for negative outcomes. This effect is known as the 'fundamental attribution error' (Miller & Ross, 1975).

The aspiration for positive self-image leads to a tendency to compare oneself to others and 'self-evaluate' which is often done in with a bias – believe that personal performance is better than the average. The same applies for people's assessment of the groups with which they identity (Dolan, et al., 2012). The definitive example of this effect is sports fans' biased or often embellished memories of their team's performance in a match, in comparison with opponents'.

Ego plays a role in the effectiveness of many nudges. Blumenthal-Barby and Burroughs (2012) discuss the examples of putting mirrors in front of donuts and calorie counts on menus. These tactics make use of salience and affect, as well as ego. The salience has an impact because people are particularly concerned with looking good and not necessarily with being healthy.

Dolan, et al. (2012) further suggests that efforts to combat smoking should take into account that smokers behaviour may be related to self-image, which means messaging related to self-esteem may be effective to motivate change. For example, pointing out that smoking causes yellow teeth, wrinkles and impotence may reduce smoking and encourage cessation.

Another tactic effective for people with lower self-esteem is to build their sense of self-efficacy discussed by (Dolan, et al., 2012). People like to think of themselves as self-consistent. When people's behaviour and self-beliefs are in conflict, it is often beliefs that shift, rather than behaviour. Thus, getting someone to comply with a minor action, such as filling in a short survey or interacting with a sample product, motivates for following through with more significant action such as purchasing a product. Once they have made the initial small change to their behaviour, the powerful desire to act consistently takes over – the initial action changes their self-image and gives them reasons for agreeing to subsequent requests. In other words, small and easy changes to behaviour can lead to subsequent changes in behaviour that may go largely unnoticed. This tactic challenges the conventional belief that change in attitude precedes or is required for change in behaviour. Similarly, the Pygmalion effect (Rosenthal, 1974) refers to the tendency in people to perform better when higher expectation placed on them as these expectations instil a sense of self-efficacy, leading people to believe they can deal with challenges effectively (Nielsen & Munir, 2009).

APPENDIX B: LANDSCAPE

To contextualise the research environment, this appendix serves as an industry informer analysis, and is divided into three sections:

1. An outline of the Discovery Health and its Vitality and Active Rewards programmes,
2. PI system interface design analysis
    - An interface design analysis of the Discovery Vitality website dashboard and mobile application as a 'persuasive' behavioural economics-based personal informatics (PI) system
    - An interface design analysis of four additional personal informatics (PI) systems, selected based on their applicability to the research questions.

This appendix has been compiled based on engagement with industry experts during a two-month internship at Discovery Vitality Strategic Programmes and an in-depth experiential analysis (n = 1) of PI systems. Persuasive (behaviour economic) and mindful design strategies are referenced throughout.

1. Discovery Health, Vitality and Active Rewards

"[Medicine] is not a pure science, but is part of an economic system and of a system of power. It is necessary to determine what the links are between medicine, economics, power and society in order to see to what extent the model might be rectified or applied" (Foucault, 2004, p. 19).

Institutions are showing growing interest in the commercial potential of data tracked by personal informatics (PI) systems, for health, lifestyle and behaviour management of relevant stakeholder groups, leading to the emergence of new business models, with greater mutual accountability and the ability to capitalise on its ability to improve health outcomes. Discovery, a global financial services and insurance provider, is fronting this advance with its shared value approach and [arguably] inclusively innovative business model, exemplified by Vitality, the insurer's behavioural economics based wellness programme.

Vitality has a member base 1,7 million people in South Africa and is available to Discovery clients on a voluntary basis at a nominal monthly fee. The premise is to reward members for leading healthier, more responsible and balanced lives, to improve their wellbeing, reduce morbidity and mortality rates, while reducing their risk profiles, in turn resulting in fewer claims for the insurer.

By joining the programme, members opt in to be nudged towards healthier habits. The programme can thus be described as a Libertarian Paternalistic system (Thaler & Sunstein, 2008) which offers value across three levels – to the individual, the insurer, and the greater culture in which it is collectively embedded. Members are consensually nudged towards healthier choices and wellness promoting behaviour by various persuasive strategies, specifically behavioural economic tactics, most prevalently, benefits and incentives.

Vitality member benefits include subsidized access to national fitness club chains (e.g. Virgin Active, Planet Fitness, Curves and others) and outdoor events (for example Parkrun, Run/Walk for Life, national sporting events calendar and others) to encourage physical activity, discounts and partial repayments (cash-backs) from strategic national retail partners on specific wellness related products and services, including nutrition (healthy food, from Woolworths and Pick n Pay), fitness products (healthy gear, from Totalsports and Sportsman's Warehouse) and lifestyle products (healthy care, from Clicks and Dischem) as well as discounts on lifestyle enhancing services, e.g. from cinema and airline tickets (framed as lifestyle enhancing stress relief, from partners such as Ster Kinekor, British Airways, Qantas and Kulula).

Incentives to further encourage regular participation in preventative wellness activities, are rewarded on the basis of a point system which contributes to an annual tier status, which, in-turn, results in escalating benefits by tier, i.e. greater discounts and cash-backs. Members can earn points for a range of activities (categorised by Vitality as 'Online Health Assessments', 'Know Your Health', 'Health Checks', 'Buy Healthy Food' and 'Get Active') and include completing various online health assessments, a non-smokers' declaration, going for professional preventative health screenings and assessments, making healthy food purchases, losing excess weight and for participating in physical activities, including gym attendance, participation in recognised sports events and for tracking workouts by means of various

partner fitness devices and applications (PI systems). These partner PI platforms are integrated with the Vitality system to share activity data, such as step count, duration, speed, distance and heart rate, which in turn determines eligibility for various tiers of point allocation. The integration of the Vitality PI system with external partner systems enables members to earn points for physical activities performed outside of the confines of partner fitness clubs, studios and organised events – an early programme limitation – contributing to the company ideal, "Vitality [points] Everywhere". Members can thereby earn points for a more holistic range of activities including movement performed throughout their day, contributing to a daily step count goal, as well as sports like outdoor cycling, running, soccer, etc.

Point allocation for various activities is determined by the verifiability, intensity and duration of activities, as indicated by various metrics, including fitness club check-ins or card swipes at gyms (low verifiability) and daily steps, speed and average heart rate (high verifiability) over time, as tracked by partner PI systems. Longer, more intense workouts, verified by trusted partner PI system data, are awarded with more points than unverifiable or lower intensity activities such as fitness club check-ins, step counts and shorter workouts at lower average heart rates. Members are thereby nudged towards training harder while being encouraged to use partner PI systems to track workouts and provide more detailed and accurate behavioural data. The table below outlines point allocation for various categories of activities, recorded according to various metrics.

Fitness points	50	100	200	300
Workout activities		Health clubs Round of golf VitalityFit Preggi Bellies Run/Walk For Life		parkrun Run/Walk For Life 5km+
Steps	5 000 – 9 999 steps*	10 000+ steps		
Speed workouts		30+ min		
Light workouts at 60 – 69% of max heart rate		30+ min*		
Moderate workouts at 70 – 79% of max heart rate			30 – 59 min	60+ min
Vigorous workouts at 80%+ of max heart rate				30+ min

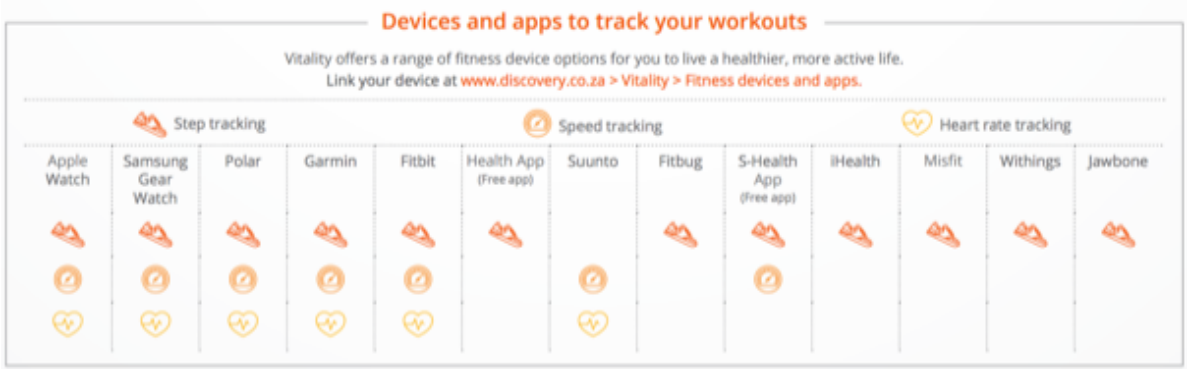
Earn speed workout fitness points by:

Running at an average of 5.5+ km/hr
Swimming at an average of 1.5+ km/hr
Cycling at an average of 10+ km/hr

Heart rate target tip:

Calculate your maximum heart rate by subtracting your age from 220.

Use this easy guide for more info.



Active Rewards

In September 2015 Vitality launched Active Rewards (AR), a programme designed to offer members more immediate (weekly) incentives, to complement Vitality's traditional longer-term (annually tiered) process for rewarding healthy behaviour, thereby motivating more consistent physical activity as well as increased member engagement. AR product development was based on hyperbolic discounting – the behaviour economic insight which recognises that people prefer smaller, more immediate payoffs to larger, more distant ones. Points earned for each qualifying activity contribute to a personalised weekly points goal, which, when achieved, is rewarded weekly, by means of a smoothie or a coffee from national partners, Kauai and Vida e Cafe. The weekly point goal is dynamic and personalised, based on an algorithm which adjusts the target according to the member's performance, to gradually encourage increased activity and improved physical fitness over time (hypothetically speaking).

AR further harnesses behaviour economic principles of goal tracking, gamification, commitment and ego by dynamically displaying progress toward achieving the goal. Furthermore, there is a social component to it whereby users can invite friends and are then given more rewards when their friends also achieve their goals. Friends can further track each other's progress, thereby creating extra motivation.

The Apple Watch Benefit

Taking this innovative approach a step further, Vitality partnered with Apple, to offer its members (who have a Discovery credit card) an Apple Watch benefit. The Apple Watch is a state of the art smart watch with advanced activity tracking capabilities, including a pedometer and heart rate monitor, which enable users to track activities that contribute to weekly AR points goals. Members who take advantage of this benefit receive the device and,

provided the member meets his/her weekly AR goals, no payment is required. If a member fails to do so, an instalment, based on the amount of weekly goals not reached in a particular month is deducted from their Discovery credit card account (a prerequisite for the benefit is that the member must be a card holder, serving as a guarantee for Discovery). The BE insight of loss aversion is leveraged as the incentive is framed as a possible charge that will be imposed if people fail meet their weekly training goals.

Unprecedented success

Though still in its infancy, the Active Rewards programme far exceeded expectations and targets. Within the first two months after the launch, Discovery smartphone application usage more than doubled (J. Vos, personal communication, November 24, 2015). Furthermore, Active Rewards has been its most successful benefit to date, with more than 160 000 activations by March 2016 almost tripling the company target (J. Vos, personal communication, March 2015). Partner PI systems and the fitness device industry in South Africa experienced an immediate surge in sales, with a 400% year on year increase in December 2015 (F. Thorpe, personal communication, February 9, 2016).

From early data, good goal completion ratios have been seen across the board. In addition, people with friends linked to their AR profile have a significantly higher goal completion than those without and the completion ratio increases for every extra friend linked. (J. Vos and K. Johnson, personal communication, November 24, 2015)

The Apple Watch benefit was launched in December 2015 and by March 2016 over 20 000 members had taken advantage of the Apple Watch deal. The annual target had been met within three months of the launch date. One could frame this initiative as a novel and unconventional business model that users can thus essentially pay for a device, which is worth over R6 000, with the steps and heart beats that it tracks, over the course of the 2-year contract. The cost is subsidised by Discovery, who justifies the expense by the projected reduced risk profile of the user/member resulting in fewer claims. Further benefits for Discovery include a surge in credit card applications, not to mention extensive local and international word of mouth and PR coverage of this pioneering initiative, resulting in unprecedented marketing value, entrenching the company's image as a progressive global innovator.

Unintended consequences

Although the insurer is already seeing a promising effect on the behaviour and health prognosis of members, particularly in sedentary, overweight and smoking segments (S. Viranna, personal communication, April 12, 2016), during early phases after the Vitality AR launch, a number of issues started surfacing pertaining to unintended ways in which members were using it. That said, Vitality has always been clear that the programme is under constant revision and that tweaks and changes for improvement is part of the process. Furthermore, in parallel with the launch of AR, a massive surge in user adoption of wellness focused PI systems has been seen in the South African market. This has further accelerated a revelation of different ways in which individuals use and respond to these tools, providing valuable insight into the greater effect of BE strategies as applied in these systems, specifically in the wellness context. Here too, some effects are unexpected and unintended.

Some of the challenges that have surfaced during the first six months of AR include:

- Gaming and cheating
- Loss aversion, resistance to change and public dissatisfaction
- Maladaptive training behaviour

Gaming and cheating

It became apparent that a large cohort of members was gaming – cheating – the system, finding ways to earn points without actual engagement in physical activity. For example, speed data revealed that members were tracking vehicle commutes with the GPS based cycling and running application, Strava, logging these commutes as cycles. Pedometers such as Fitbits, Jawbone Ups and Withings devices were being attached to dogs and objects that emulate similar movements, (for example, ceiling fans), to help reach a high daily step goal. In response, a revision was made to the conventions according to which partners had to supply data and subsequently, the list of recognised partner applications and devices, favouring clinically verifiable data. The rules for point allocation which became more stringent, requiring users to work harder to earn points.

Loss aversion, resistance to change and public dissatisfaction

The changes to point allocation rules were met with an extreme reaction from many members, who publicly reacted via social and traditional media, causing inordinate upheaval

for the Vitality AR member base, the organisation and exorbitant controversy for the brand. As such, a vivid example of effects of BE strategies, specifically incentives, and related dynamics that involve the establishment of anchors, reference points and resulting loss aversion when theses reference points change, were evident. It could thus be argued that the extreme reactions were irrational in the context of the objective of the programme – a behavioural economics based wellness programme of which individuals are members by choice, implicitly consenting to optimal behavioural change strategies. This has had major brand, communications and reputation management implications for Discovery Vitality and the overarching Discovery brand.

Maladaptive training behaviour

- Compromised safety – chasing goals at the expense of wellbeing
    - Feeling pressure to train while undergoing medical treatment.
    - Neglecting to take chronic medication, for example, arrhythmia medication that slows down heart rate to ensure a higher average heart rate to guarantee earning points.
    - Ignoring natural biofeedback, for example, pain and exhaustion, in order to reach a numerical goal, causing injury, pushing beyond what is healthy, necessitating physiotherapy and medical care.
- Compromised enjoyment
    - Distraction by application device usability, e.g. obsessing about numbers, calculating average heart rate, or frustration with inconsistent and problematic heart rate sensors (particularly the wrist-based Apple Watch).
    - Changing previously enjoyed activities for the sake of better track-ability of an alternative, e.g. giving up swimming for running.
- Futile and counterproductive activities
    - Fitness club check-ins without actually exercising.
    - Consuming more high sugar beverages due to nutritional content of rewards (Kauai and Vida e Caffe).

Valuable learning: Failing forward

Nevertheless, the Vitality Active Rewards programme and the Apple Watch benefit are bold and innovative endeavours, launched on a massive and ambitious scale. Drawing on a ‘fail forward’ approach (Maxwell, 2000), iteration is part of the process and the learning is

immensely valuable, not only for Discovery, but also for the broader context of behavioural health intervention system designers and policy makers.

2. PI system interface design analysis

To facilitate deeper insight into PI system interface design, an analysis of popular PI system interfaces is presented in the following section. Principles outlined by the stage-based model of PI Systems (Li, Dey, et al., 2010) as introduced in the literature review, are referenced. Furthermore 'Persuasive' and 'Mindful' design strategies are identified throughout. 'Persuasive' features refer to components that draw on BE principles, and activate 'System 1' type reactions from users. 'Mindful' or 'Reflective' features refer to design mechanisms that require and facilitate deeper 'System 2' type engagement and self-reflection, leading to personal insight. The PI system selection criteria are based on the relevance of the PI interface design mechanism to illustrate the key elements of theory, and not necessarily on the popularity of the system. The selection is outlined in the table below.

	PI System	**Platform / Medium**	**Facets (Uni / Multi Faceted)**	**Driver - Data Collection (System / User Driven)**	**Driver - Data Integration (System / User Driven)**	**Dominant Style/ Design Strategy (Persuasive / Mindful Design)**
1.	Discovery Vitality	Website Mobile App	Multi	System and User driven	System driven	Persuasive
2.	Strava	Mobile App	Fitness	System driven	System driven	Persuasive
3.	Apple Workout	Mobile App	Fitness	System driven	System driven	Persuasive
4.	MyFitnessPal	Mobile App	Nutrition	User driven	System driven	Persuasive
5.	Minding the Food Space	Paper-based handouts	Nutrition Fitness Mood	User driven	User driven	Mindful

2.1 Discovery Vitality

PI System	Platform / Medium	Facets (Uni / Multi Faceted)	Driver - Data Collection (System / User Driven)	Driver - Data Integration (System / User Driven)	Dominant Style/ Design Strategy (Persuasive / Mindful Design)
Discovery Vitality	Website Dashboard Mobile App	Multi-faceted • Wellness • General • Nutrition • Fitness • Mental • Driving	System and User driven	System driven	Persuasive

Platform / Medium:

Website Dashboard and Mobile Application

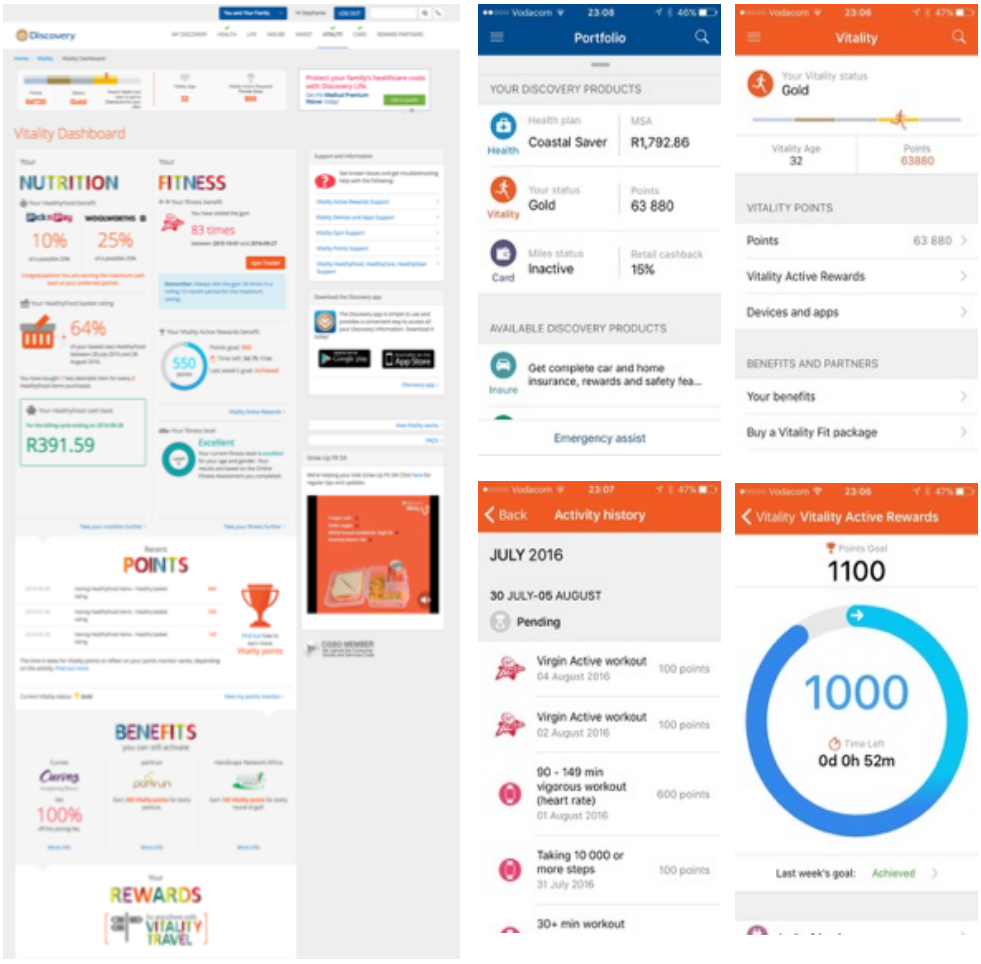


Figure 7: Vitality Website Dashboard and Mobile Application

Facets:
Multi-faceted

- Wellness
- General Health
- Nutrition
- Physical Activity
- Mental Wellbeing
- Driving

Drivers: Data collection and integration:
System and user driven combined

Multifaceted data sets, as outlined above, are collected via combination of native Vitality systems, external partner systems as well as manually collected by the user. Data collection is thus both system – and user-driven.

These multifaceted data sets from internal and external data streams are integrated by the Vitality system which processes the information to duly allocate points to the member's profile, resulting status progression, escalating benefits and rewards respectively. Members can keep track of these key parameters (point eligible activities, points, status, benefits and rewards) via the website dashboard and mobile application where information is relayed back to the user.

The full range of behavioural data for which members can earn points is outlined below, categorised according to the driver:

System driven
Points are allocated according to data collected and aggregated through integration with a wide range of native Vitality and external partner platforms:

- Wellness
    - Result of multifaceted data aggregation and integration
        - Vitality Status

        - Vitality Age
- General Health
    - Integration with partner health care professionals (HCPs) providing data from preventative screenings
        - Partners and parameters:
            - Health check – blood pressure, glucose, cholesterol and weight
            - Vitality Fitness Assessment – Biokineticists
            - Vitality Dietary Assessment – Dieticians
            - Colonoscopy – Doctors
            - Glaucoma screening – Optometrist/Eye Specialist
            - HIV test – Doctor or Pharmacy
            - Pap smear – Doctors
            - Mammogram –Radiologists
            - Dental Health Check-up – Dentist
- Nutrition (Healthy food purchases)
    - Integration with retail partners providing all food purchase data
        - Partners: Woolworths, Pick n Pay
        - Parameters:
            - Healthy food basket rating
            - Cash-back amount
- Physical Activity
    - Integration with national fitness club partners
        - Partners: Virgin Active, Planet Fitness, Curves, Preggi Bellies, Adventure Bootcamp, SWEAT 1000, Crossfit, Vitality recognised independent fitness studios, sports clubs and corporate gyms
        - Parameters:
            - Membership card entry ‘swipes’
            - Check-ins via dedicated tablet based Vitality points device stations in reception areas at facilities
    - Outdoor fitness partner integration
        - Partners: Parkrun, Run/Walk for Life, Vitality Race Events Handicaps Network Africa (Golf)
        - Parameters:

        - Race Registration
        - Check-ins via dedicated tablet based Vitality points device stations at facilities / events
    - Partner PI systems platform integration (apps and devices)
        - Partners: Apple (Health, iHealth, Workout Apps, Apple Watch), Samsung (SHealth App, Samsung Gear), Garmin, Polar, TomTom, Suunto, Fitbit, Jawbone, Withings, Misfit, Fitbug
        - Parameters:
            - Average heart rate/Time
            - Speed/Time
            - Daily Step count
- Road Safety
    - Vitality Drive vehicle tracker integration
    - Parameters
        - Detailed driving data

User-driven

Points allocated for data collected through manual input by user via online assessments

- Online Vitality Age Assessment
- Online Fitness Assessment
- Online Mental Wellbeing Assessment
- Online Non-Smokers Declaration

Dominant design style and strategies

Persuasive design style and strategy

Multifaceted aggregated data (as outlined above) is integrated by the Vitality system and relayed back to the user in a style that reflects the behavioural economic foundations of the programme. The emphasis of the key tracking parameters (for example, points, status, Vitality Age, benefits and rewards), the types of visualisations, as well as the language used to convey information, are implicitly centred around ‘achievement’ and ‘striving’ with a ‘competitive’ style. The system thus exemplifies ‘persuasive’ design strategies. These

strategies, in turn, pre-empt specific styles of user engagement, personal reflection and, ultimately, influence action and behaviour.

The following section identifies specific components of the Vitality website dashboard and mobile app interfaces that illustrate these 'persuasive' design strategies and characteristics and highlights application of BE insights and principles.

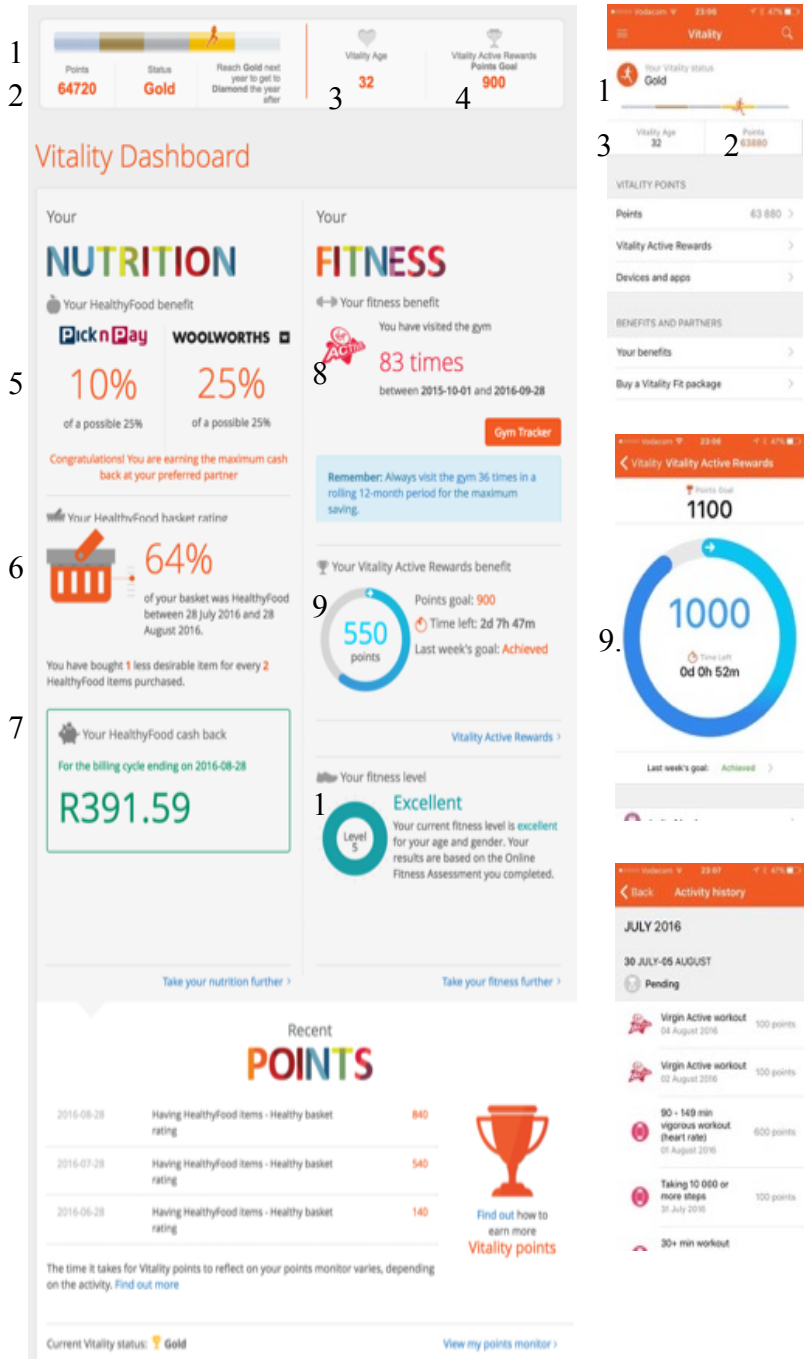


Figure 8: Vitality website dashboard and mobile app interfaces - Components illustrating 'persuasive' design strategies and characteristics are numbered and discussed accordingly below

Overall Wellness: Status, Points and Vitality Age

The primary focus of the Vitality dashboard landing page (both website and mobile app) is an overarching view of the user's Vitality programme progress, specifically Vitality status, total points (year to date), and Vitality Age – hypothetically, the member's overall wellbeing.

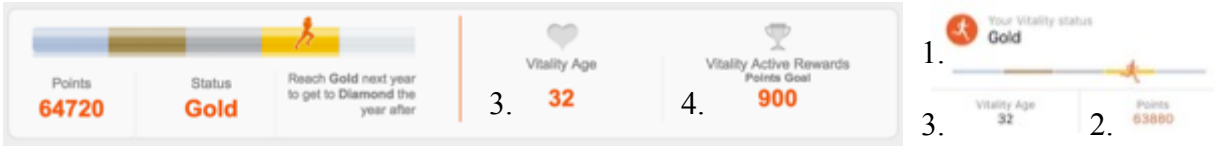


Figure 9: Vitality Status, Points, Vitality Age and Active Rewards

1. **Vitality Status** is indicated by a status bar overlaid with a figure of a runner who progresses along from blue to silver to gold and ultimately diamond as the member advances.
2. **Total Points** collected (year to date) is clearly indicated in bright orange.
3. **Vitality Age** is calculated according to user online assessment, is emphasized.
4. **Vitality Active Rewards** weekly points goal is included in the website dashboard.

Persuasive BE Strategies:

- The positioning of this component in the primary 'real estate' of the page leverages BE principles of Priming and Salience.
- Numeric and tiered motivational tactics of points and status bar further reflect the BE strategies of Incentives, Ego and Goal Progress, and leverages the BE insight of Loss Aversion.
- One could argue that the choice of terminology and language used (for example, 'status' and 'age') draw on the BE principle of Salience.

Nutrition and fitness

Nutrition and healthy eating habits are tracked by means of food purchase data provided by retail partners. Nutritional progress are indicated by the following parameters and relayed back to the user by the following components:

5. **HealthyFood Benefit** is indicated by boldly displaying the numeric cash-back percentage for which the member qualifies based on his/her status, at retail partners, Woolworths and Pick n Pay.
6. **HealthyFood Basket Rating** emphasises the numeric percentage of the member's food purchases at retail partners which was comprised by healthy food choices over the past month.
7. **HealthyFood Cash Back** accentuates the monetary value of the repayment the member received in the past month, based on the HealthyFood Benefit percentage and actual healthy food purchases made at retail partners.

Fitness performance and progress are reflected through of Gym Visits, Active Rewards Goal Progress and Fitness Level. Fitness progress is indicated by the following parameters and relayed back to the user by the following components:

8. **Fitness Benefit** boldly indicates the number of times the user has visited the gym, encouraging the member ensure this number stays above the required amount to ensure the maximum saving through the resulting subsidised gym membership fee.
9. **Active Rewards Benefit** graphically highlights the member's progress towards reaching his/her weekly goal by means of a circular 'donut' graph and numeric indicators.
10. **Fitness Level** is indicated by labels ranging from 'poor' to 'average' to 'good' to 'excellent' drawing on the data supplied by the member when filling in tan online fitness assessment to estimate individual activity levels.

Persuasive BE strategies:

- Numeric motivational tactics of displaying percentages, ratings and counts as well as graphically represented goal progress by means of 'donut graph', reflect the BE strategies of Incentives, Ego and Goal Progress, as well as leveraging Loss Aversion.
- The choice of terminology and language used to describe fitness level ('poor', 'average' 'good', 'excellent' draw on the BE principles of Norms and Salience.

Vitality points monitor

11. **Recent Points** integrates and displays a chronological list of all recent recorded activities for which the user has earned points. The user can click through to access all points

events, over time. This interface design component thus provides the most comprehensive view of combined wellness related activities and behaviours as tracked by the Vitality system. Evidently, focus is placed on the number of points earned for each activity, which contributes to overall member status (resulting in greater benefits and rewards) and weekly Active Rewards goals, resulting in smoothies, coffees and aversion of Apple Watch repayments.

Persuasive BE strategies:

- Once again, the numeric motivational tactics are applied by emphasis on point allocation, relying on BE strategies of Incentives and Goal Progress, as well as leveraging BE principles of Ego and Loss Aversion.
- It must be noted that even though not relayed through the Vitality dashboard, Discovery further has access to a far broader range of behavioural data parameters, based on each member's unique product portfolio, including family information, doctors' visits, treatment information, credit card transactions, pharmacy purchases, driving data, claims data, etc.
- Combining these comprehensive data sets and relaying information back to users in more dynamic and meaningful ways, to create context and reveal correlations to complement the current single-minded focus on points, scores and percentages, has the potential to provide far more significant user engagement, reflection and insight into personal user behaviour and to, in turn, assist members in gaining better understanding and subsequently taking greater responsibility for their own health. It further offers potential to foster stronger relationships between the Discovery (Vitality) brand and its clients.

2.2 Strava

PI System	Platform / Medium	Facets (Uni/ Multi Faceted)	Driver - Data Collection (System / User Driven)	Driver - Data Integration (System / User Driven)	Dominant Style/ Design Strategy (Persuasive / Mindful Design)
Strava	Mobile app (Website dashboard underutilised)	Uni-faceted • Fitness	System driven	System driven	Persuasive

Platform

Mobile application

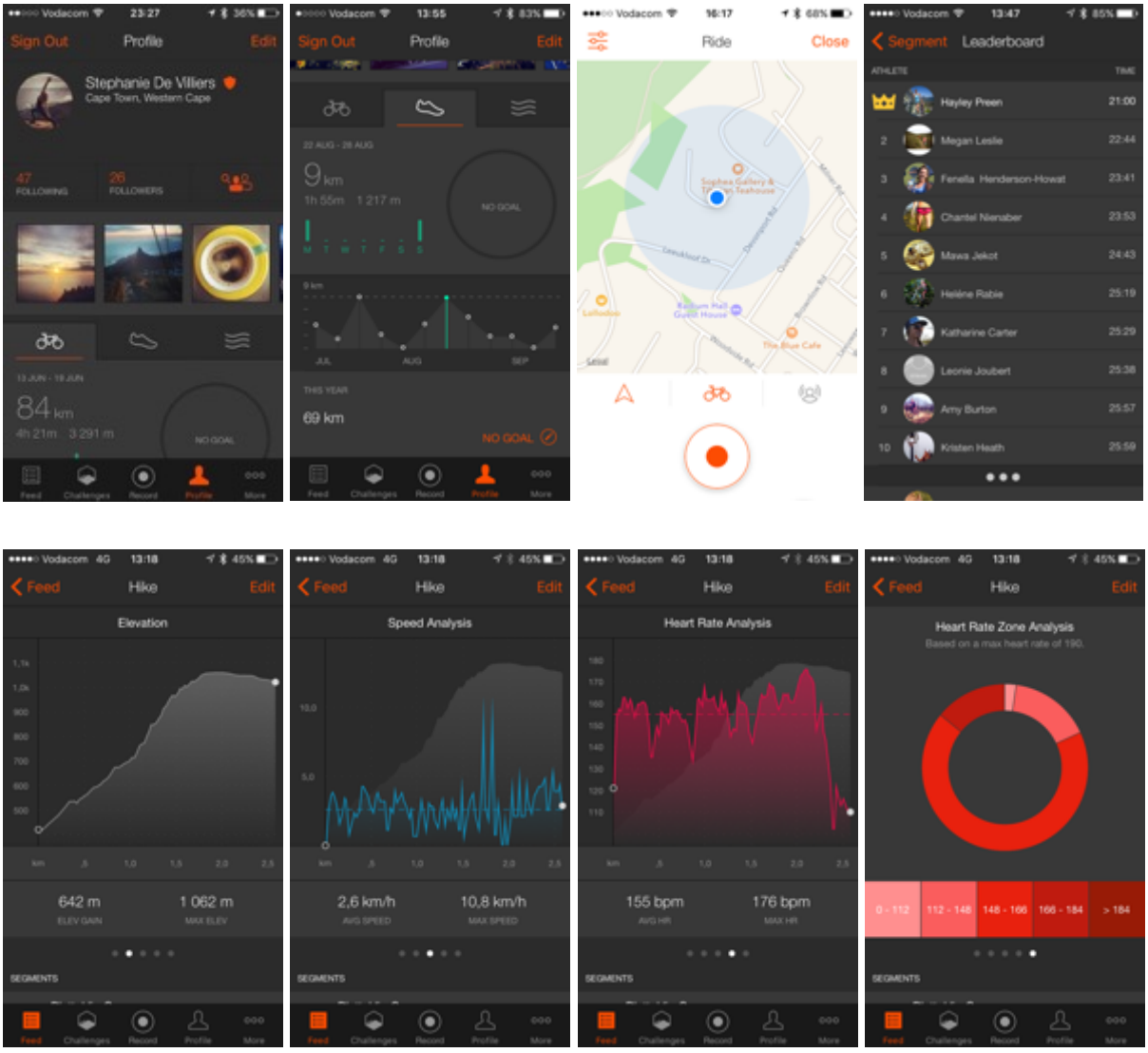


Figure 10: Strava Mobile Application

Strava is a website and mobile app with a large global (some argue 'cult') following used to track athletic activity via GPS, the most popular activities being cycling and running. The system allows users to track and upload their activities using predominantly GPS data either from Strava's dedicated smartphone application or via a third-party GPS based fitness devices such as Garmin, providing parameters such as distance, pace, speed, elevation gained, estimated calories burned, power output and heart rate. Ride and running routes are displayed on a map and divided into user generated segments. Activity performance per segment is recorded and plotted on a leaderboard, allowing users to compare performance other users' performance, to track their own ranking and to compare with their own past performance. Personal Records (PR), King of the Mountain (KOM) or Queen of the Mountain (QOM) trophies, crown symbols and badges are awarded to fastest times, providing further motivation. Strava further allows athletes to follow each other, give 'kudos' and to comment on each other's activities. Photo uploading functionality and Instagram integration allows for photosharing and further, more visually salient recording of activities. In addition, users can join a range of motivational challenges, such as those which set distance or climbing targets. These capabilities have made Strava into a form of social media, as well as serious training tool enabling motivation and performance comparisons with others from all around the world. In many ways, Strava has thus revolutionised the way in which athletes track their activities, communicate, compare their efforts and find motivation to improve.

Facets:
Uni-faceted

- Physical activity (primarily, but not exclusively, GPS based)

Drivers: Data collection and integration:
System Driven
Uni-faceted physical activity related data sets (primarily, but not exclusively, GPS based) are collected via the Strava smartphone application and / or a long list of external third party partner GPS based PI system devices, including industry leaders, Garmin, Polar, Suunto, TomTom and Fitbit. Data collection is thus system driven.

These data sets from internal and external data streams are integrated by the Strava system that processes the information to display activity performance information in conjunction with segmented maps past performance stats and leaderboards. Members can easily keep track of and reflect on these key GPS based parameters (e.g. location, speed, distance, ranking, elevation gained, estimated calories burned) as well as more detailed performance metrics tracked by third party devices (e.g. power output, cadence and heart rate) via the platform.

Dominant design style and strategies
Primarily persuasive design style and strategies

Strava's primary focus on GPS-based activity tracking, informs the system design and user experience which is location (route), time, distance and speed based which further leverages its large community of avid athletes, the comprehensive data sets they generate, along with their distinct behavioural idiosyncrasies. This combination produces powerful nuances, resulting in a platform with a competitive style, which allows users to not only race against other athletes, but also to compare and compete against their own and others' past performance. It further exploits the powerful inherent social potential, enabling likeminded athletes (and fanatics) to connect, support and compete while publically sharing their experiences and passions, expressing their individuality and showcasing their talents and activities through the Strava app as well as thorough third party social media platforms (Instagram, Facebook and Twitter).[9]

Although the emphasis is predominantly on 'persuasive' design strategies, (aligned with the competitive nature of the sports that Strava tracks), easy user access and clear visualisation of comprehensive user data (specifically for premium users), provide opportunity for reflective user experiences. The researcher therefore argues that 'mindful' design strategies play a secondary and complimentary role in the Strava PI system interface design.

[9] The Social Facilitation Theory argues that social evaluation has an impact on performance. The psychologist Norman Triplett was the first to study this effect, starting in 1898. He found that cyclists had better race times when in the company of other cyclists. Further research demonstrated something we now consider obvious: humans try harder when matched against others. Later work would demonstrate that the mere presence of others could inspire us to work harder.

The researcher further contends that Strava exemplifies key characteristics of Positive Technology (Graffigna, et al., 2013) – as introduced in the literature review – as it contributes to developing the three defining dimensions that serve to promote adaptive behaviours and positive functioning in its users i.e. emotional quality (hedonic or enjoyment level), engagement/actualisation (eudaimonic or wellness level), and connectedness (social and interpersonal level) by its harnessing of sport and leisure, exercise and social engagement.

The following section identifies key components of the Strava interface that illustrate its primarily 'persuasive' design style and complimentary 'mindful' design strategies which, when combined, offer a robust example of (an increasingly popular) Positive Technology.

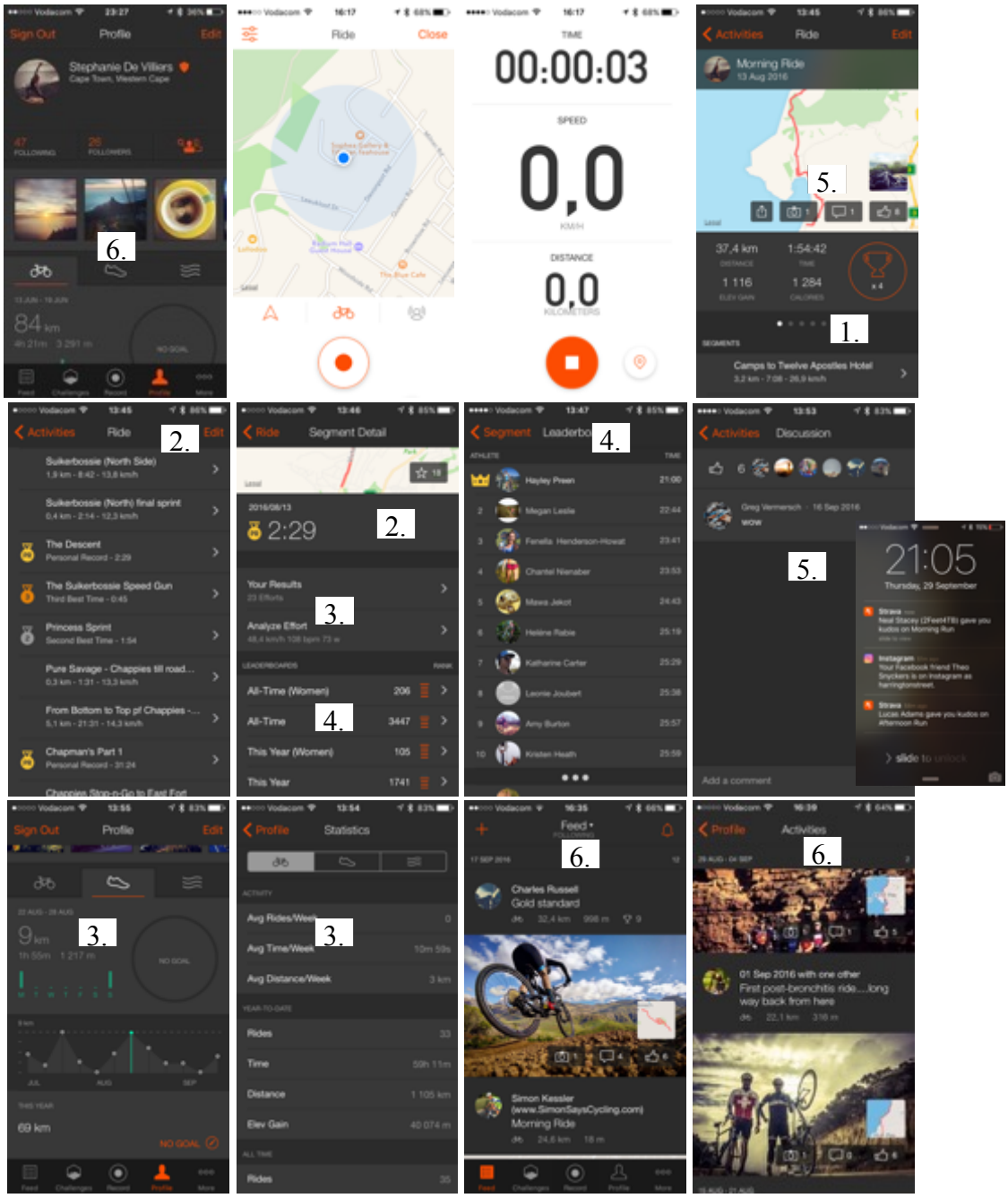


Figure 11: Strava mobile app interfaces - Components illustrating 'persuasive' and 'mindful' design strategies and characteristics are numbered and discussed accordingly below

1. **The detailed activity log indicates key parameters tracked by the GPS system, including** the route plotted on a map, distance, time, elevation gain and estimated calories. Particular emphasis is placed on the number of run or ride segments which the athlete completed within a top three personal best time, with an orange trophy graphic.
2. **Segments** data in list format follows the key parameters. Segments that have been completed in a top three personal best time is marked with medal graphics – Gold PR for

a personal record, Silver 2 for second best time and Bronze 3 for third. This provides the Strava system ample opportunity to 'recognize' and 'reward' the athlete for many small, manageable victories throughout a single activity - a particularly effective (and addictive) motivational and tactic. To complement this persuasive strategy, the user can further click through to reflect on segment data in greater detail.

3. **(Segment) Past performance and effort analysis** is available for users to reflect on performance and progress over time and to analyse results in greater detail to gain feedback and insight into dynamics influencing performance, supporting a more mindful stance.
4. **Leaderboard comparisons** are accessible enabling athletes to see how they rank in comparison to other athletes, providing a powerful progress tracking and incentivising mechanism. Users can compare their effort to the entire Strava community who have tracked the same route, as well as to specific groups, i.e. athletes of the same gender, age group and weight. Users can further see how their performance compares to other athletes' within a set time bracket, i.e. the past year or even on the same day – particularly relevant on race days. The user with the fastest time per segment is assigned with a King or Queen of the Mountain crown badge (KOM / QOM).
5. **Social engagement – Kudos and comments** – are system features which encourage social interaction, acknowledgement from the community, support and even some light / fun athlete's banter. Athletes training together and tracking activities at the same time and place are automatically linked on the platform. These features are powerful in cultivating the Strava culture and in creating connection and cohesion among athletes and friends (from all over the world) who do not necessarily train together, but share a love for their sport.
6. **Personal Expression** is stimulated by various system features, including photo sharing capability, allowing users to seamlessly upload photos of their activities from their phones and even from the popular Instagram app, creating a visual activity diary of sorts in the user's personal activity feed on the system. Users can also assign unique titles to their activities, often humorous, referring to circumstances contextualising the event, e.g. "First post bronchitis ride …" providing an explanation for a slow performance or "Gold Standard" for a session in perfect conditions. These features further assist in contextualising the athlete's performance during a particular activity – a valuable aspect particularly from a self-reflection perspective.

Persuasive and mindful design strategies:

The outline above reveals smart tactical application of many 'persuasive' strategies and BE insights in the Strava system design as well as features that promote more 'mindful' user engagement. Examples are outlined below:

- Providing clear, relevant performance metrics of each activity provides simple yet well-defined numeric Incentives.
- Strava maximises opportunities for providing users with Incentives by dividing single activities into multiple smaller segments and acknowledging users' performance accordingly.
- The use of leaderboards leverages the Norms principle, by setting a community standard, as well as the Ego and Incentives principles by creating a context that encourages personal advancement that results in public recognition.
- Social integration and interactive capabilities further leverage the principles of Messenger and Ego by exploiting the power of social influence (particularly that of respected peers and top athletes in the broader community) and the natural need for humans to look good and uphold standards among peers.
- Although primarily persuasive in nature, the system structure and design also lends itself to powerful reflective user experiences, complementing the goal orientated, 'striving' (Strava) style and competitive emphasis. Detailed past performance and effort analysis features provide valuable biofeedback in an accessible format and are particularly valuable in this regard. Combined with comprehensive GPS and biometric data sets, visual and linguistic self-expressive features of the platform further afford the ability to create a rich, interactive personal sports and training journals of sorts, which combines context with biometric and performance data, supporting more mindful styles of user engagement.

2.3 Apple Workout and Activity app

PI System	Platform / Medium	Facets (Uni / Multi Faceted)	Driver - Data Collection (System / User Driven)	Driver - Data Integration (System / User Driven)	Dominant Style/ Design Strategy (Persuasive / Mindful Design)
Apple Activity & Workout Apps	Apple Smartwatch and Mobile Apps	Uni-faceted • Movement / Fitness	System driven	System driven	Persuasive

Platform:

Apple Smartwatch and Mobile App

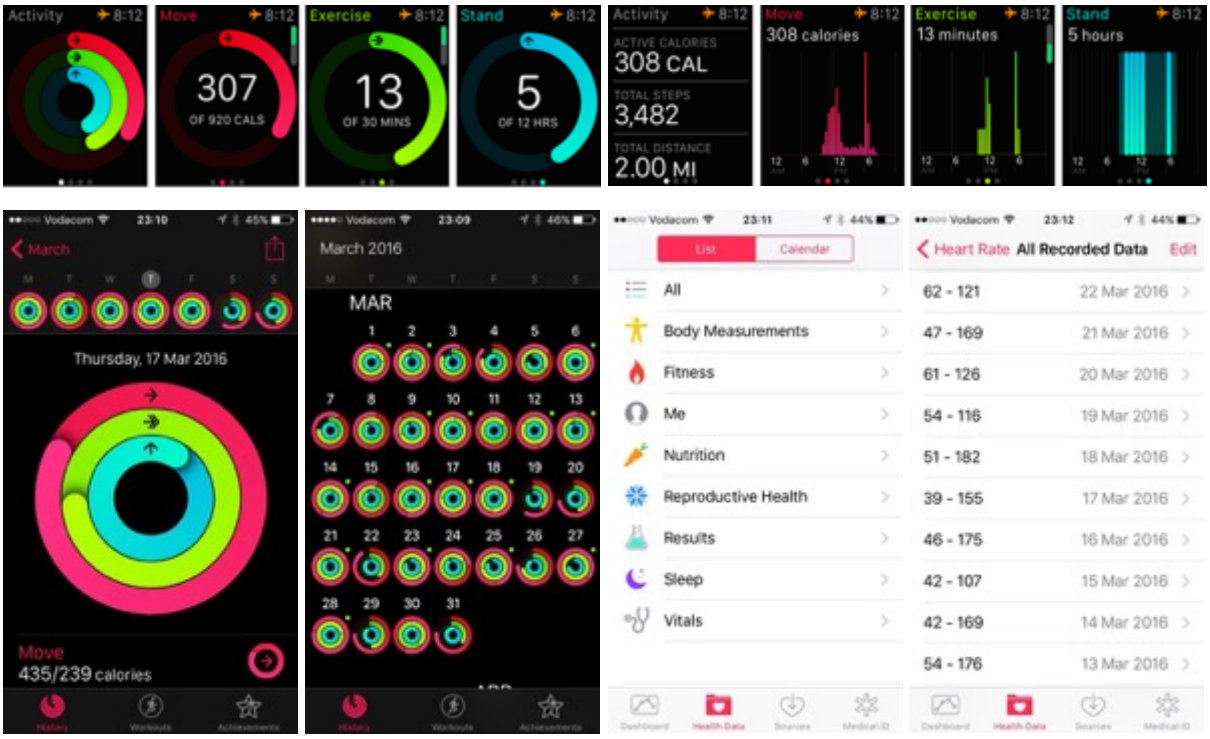


Figure 12: Apple Activity and Health Applications

One of Apple's primary goals with the Apple Watch is to provide users with tools to keep them healthy, and the Activity and Workout apps are part of that effort. These apps aim to increase the user's general activity throughout the day, using wrist based movement and optical heart rate sensors to track activity data, categorised according to three key parameters represented by three coloured rings: Red for Movement, Green for Exercise and Blue for

Stand. The rings fill up over the course of the day as the user progresses toward these 3 predetermined activity goals. The system does therefore not focus predominantly on steps and calories, as most activity trackers do, but aim to improve users' wellbeing by nudging them towards moving more consistently throughout the day (week/month/year), to create subtler, more manageable behavioural changes and foster sustainable new lifestyle habits. For example, sensory notification – light vibration – along with a wrist-based reminder nudges users to stand up and move around. The default target is to stand for at least one minute in each of at least 12 separate hours, resulting in a full blue ring. The red movement ring fills up according to active calories burnt – calculated by movement and heart rate data – to boost daily energy expenditure. The target, resulting in a full red ring, is a clinically recommended minimum number, personalised according to user's profile. The green exercise ring represents movement that, according to heart rate and movement data, is equivalent to a brisk walk or more. Thirty minutes of such activity translates to a full green ring.

Facets:
Uni-faceted

- Physical activity

Drivers - Data Collection and Integration:
System Driven
Uni-faceted physical activity related data is automatically collected via the Apple Watch Activity application, using the movement sensors and wrist-based optical heart rate monitor of the device, which monitors the movement and heart rate of users throughout the day. The separate watch based Apple Workout app tracks detailed cardiovascular exercise session data which automatically syncs with the Activity application. Data collection and integration are thus system-driven.

Physical activity metrics further include 'move' (which includes specific times during the day spent moving and calories burnt), 'exercise' (which includes specific times during the day spent exercising and duration) and 'stand' (which includes the number of hours in the day which has been spent standing (vs. sitting or lying down). Workout data parameters include the type of activity, calories burnt, total time, distance, pace/speed, average heart rate.

Data tracked by the Workout app is further integrated with the Apple Health platform which combines aggregated data tracked from an extensive range of native Apple apps, devices as well as a wide selection of leading third party PI systems to provide a holistic view of the user's personal health with comprehensive data sets that are categorised according to Me (user profile), Body Measurements, Fitness, Nutrition, Reproductive Health, (Test)Results, Sleep and Vitals.

Dominant design style and strategies

Primarily Persuasive Design Style and Strategies

The Apple Activity and Workout apps work together in a predominantly 'persuasive' style to encourage increased activity levels, with a focus on simple but smart visualisation techniques to represent complex behavioural data that provide motivation for increased activity. The secondary accessibility of more in-depth activity data also supports reflective user experiences. Here too 'mindful' design strategies thus play a complimentary role in the PI system interface design.

The following section identifies key components of the Workout App interface that illustrate its primarily 'persuasive' design style and complimentary 'mindful' design strategies which, when combined, offer a simple but strong example of Positive Technology that crosses over into the smart watch territory.

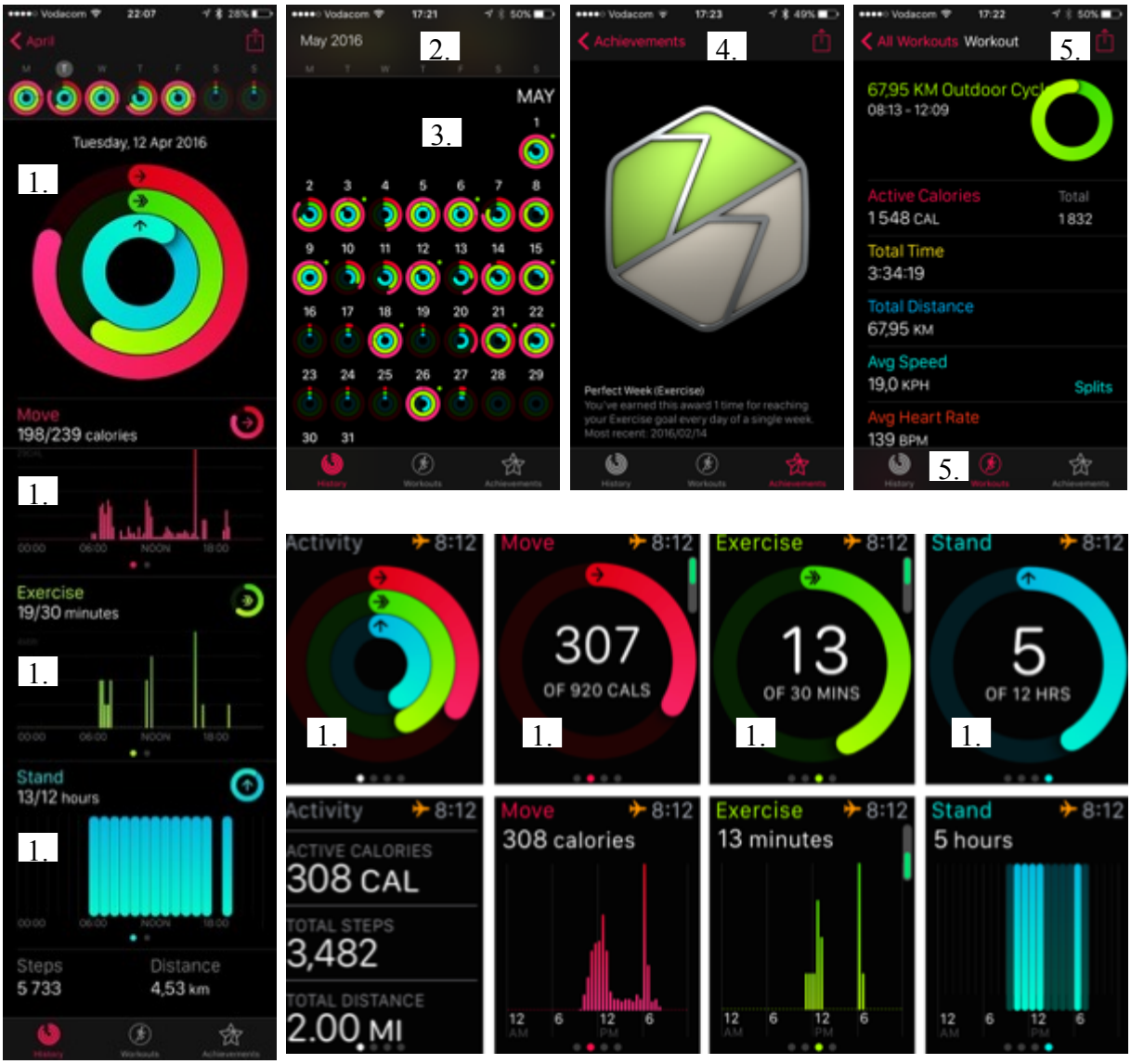


Figure 13: Apple Activity and Health Applications - Components illustrating persuasive and mindful design strategies and characteristics are numbered and discussed accordingly below

1. **Daily goal progress** is indicated through the use of popular persuasive visualisations, i.e.
   1.1. Distinctly coloured rings that fill up throughout the course of the day as the user progresses toward goal completion.
   1.2. – 1.4. Bar graphs on time lines that indicate performance of key parameters (move, exercise, stand) throughout the day to provide a more contextual snapshot of activity.
2. **Performance over time** is indicated with the three-level rings plotted on a calendar. This further creates a simple yet powerful visualisation of activity levels over time, which promotes more mindful, reflective engagement.

3. **Ample opportunity for achievement and affirmation** is available as the daily goals are relatively easy to reach, ensuring high likelihood for the user to receive regular acknowledgement from the system, ensuring continued motivation.
4. **Achievement badges** are further awarded by the system to recognise the user for performance beyond the (relatively easy to reach) default goals. A range of badges or trophies are awarded for various accomplishments for example, additional effort, consistency, new records, filling up all three rings over consecutive days, etc.
5. **Integration with Workout App** allows for user access to more detailed exercise data, nudging users to engage more deeply these feedback mechanisms, creating potential for insight into personal physical performance.

Persuasive and mindful design strategies:

The discussion above reveals smart tactical application of many 'persuasive' strategies and BE insights in the Apple Workout system design as well as features that promote more 'mindful' user engagement. Examples are outlined below:

- BE principles of Incentives and Ego thus play an important role in the Apple Activity Application, for example:
    - Similar to numeric incentivising, visual goal progress, which is applied throughout the system, most evidently by the distinct use of the circular graph emulates a quick incentive, relying on the user's psychological sense of achievement (and resulting dopamine boost) completing these circles provides.
    - Relatively easily attainable daily activity goals further support regular dopamine boosts and continued user motivation.
    - Additional recognition (and further boosting) is provided by badges for special achievements.
- The ability to visualise past performance and analyse activity data in greater depth provide valuable performance feedback to the user in a simple and accessible visual format further support more mindful styles of user engagement.

2.4 MyFitnessPal

PI System	Platform/ Medium	Facets (Uni / Multi Faceted)	Driver - Data Collection (System / User Driven)	Driver - Data Integration (System / User Driven)	Dominant Style/ Design Strategy (Persuasive / Mindful Design)
MyFitnessPal	Mobile App (Website dashboard underutilised)	Multi-faceted 6. Weight 7. Nutrition 8. Physical Activity	User driven	System driven	Persuasive

Platform

Mobile Application

Figure 14: MyFitnessaPal Mobile Application

MyFitnessPal (MFP) is a free web tool that allows users to track nutrition, exercise and weight, i.e. daily calorie consumption, expenditure and effect on weight. Its extensive nutrition database includes most foods, incorporating food items from major retailers, food chains, as well as user generated entries, providing nutritional information, i.e. calories and nutrient breakdown (flexible portion sizes). Its exercise database contains a broad range of activities along with estimated calorie burn (flexible duration). It further integrates with a

wide variety of popular third party PI systems to incorporate more accurate exercise data, including Apple Health, Strava, SHealth, Fitbit, Jawbone, Withings, etc. Users can set goals, share meals, create recipes and keep food diaries private, public, share it with MFP friends, or give it a passcode and share it that way with selected individuals such as doctors, dieticians or coaches.

Facets:
Multi-faceted

- Weight
- Nutrition
- Physical activity

Drivers: Data collection and integration:
User-driven data collection, System-driven integration
Weight, nutrition and physical activity related information is entered manually by the user. The user specifies food choices and amounts, exercise options and duration and if not part of the database, the estimated calorie contents or burn. Further, physical activity data collected by third party partner applications are automatically aggregated and collection is thus system driven. Integration is system driven as MFP processes the information and relays it back to the user in systematic ways which produce actionable knowledge.

Dominant design style and strategies
Primarily persuasive design style and strategies
The primary focus on weight tracking and calorie counting informs a design style which is predominantly 'persuasive'. Persuasive strategies include intense emphasis on numeric values – addition, subtraction, and counting down of daily calorie consumption, expenditure and allowance as well as weight. Further focus on numeric / statistical data is provided through detailed nutritional break-down. The platform does however offer opportunity for reflection and mindful engagement, through the 'nutrition' and 'notes' components, which are relatively under-utilised.

The following section identifies key components of the MFP app interface that illustrate its primarily 'persuasive' design style and secondary 'mindful' design strategies.

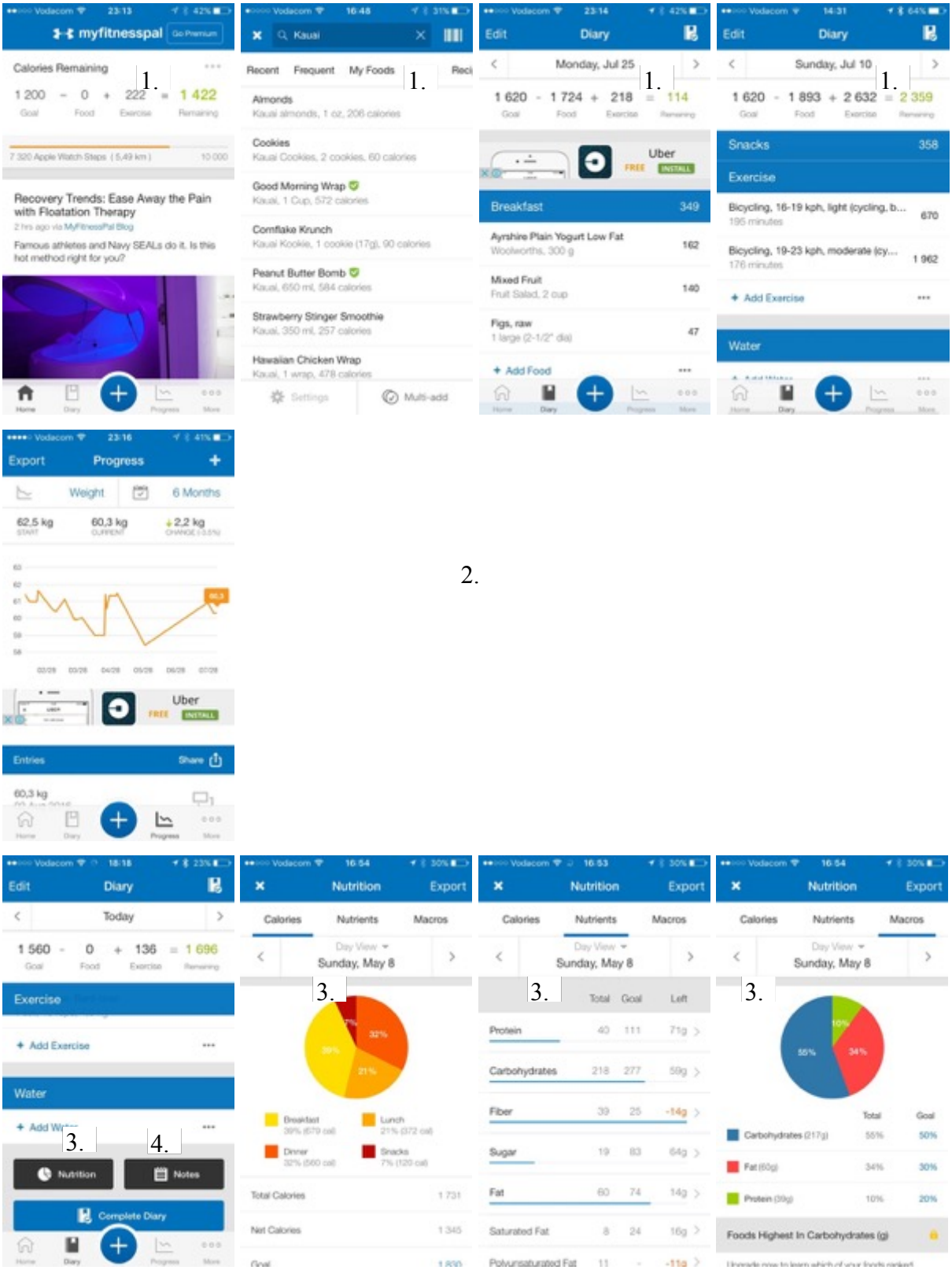


Figure 15: MyFitnessaPal Mobile Application - Components illustrating 'persuasive' and 'mindful' design strategies and characteristics are numbered and discussed accordingly below.

1. **Daily calorie goal calculation:** MFP is essentially counting calories is illustrated by the pervasive communication of calorie values, supporting numeric incentive BE strategies, for example:
    1.1. The prime positioning of the calculation of the daily calorie allowance: Calorie goal – Calorie consumption (food eaten) + the exercise calorie expenditure = remaining calories, top centre of the home page and across the pages of the most utilised diary section of the app.
    1.2. The comprehensive food choice database, displayed in list format further conveys calorie values for each item.
    1.3. Each food item and meal logged by the user displays a calorie value which is subtracted from the daily calorie allowance calculation.
    1.4. Each exercise activity logged (either manually by the user, or by automatic integration with third party PI systems), contributes a calorie value which is added to the daily calorie allowance calculation.
2. **Progress graph:** The emphasis on weight tracking in the 'Progress' section of the application, relayed by a simple yet powerful graphic visualization, further provides a numeric incentive.
3. **Nutrition:** This section of the app provides detailed breakdown of calories, and nutrients consumed in simple visualisations
    3.1. The 'Calories' page visually displays and compares calorie allocation per meal as a percentage of the total by means of a pie chart.
    3.2. The 'Nutrients' page indicates consumption, goal and remaining allowance of macro- and important micronutrients in grams, per day by means of progress bars.
    3.3. The 'Macros' page visually displays and compares macronutrient allocation per food group as a percentage of the total by means of a pie chart.

    Notes: This section of the app provides a text field for the user to manually enter additional information, an opportunity add subjective and contextual information to food choices.

Persuasive and mindful design strategies:

The points above outline a primary focus on 'persuasive' strategies and BE principles, i.e. on numeric goal progress, specifically counting calories and tracking weight. Reflective user engagement is supported to a lesser degree, but not emphasised. Examples are outlined below:

- BE principles of (Numeric) Incentives and Priming (Dolan et al., 2012) thus play an important role in the MFP Application, e.g. Numeric Incentivising (Etkin, 2014) is applied throughout the system, most evidently by means of pervasive calorie allowance calculations and goal weight tracking, placed in the most prominent position of the interface design, priming the user to keep quantitative values of food choices and exercise top of mind.
- The ability to visually track weight over time, analyse macro and micro nutrient values of food choices, offers a degree of reflectiveness to the user experience however the focus on numbers incite a persuasive style of user experience (Gao, 2012).
- The manual user driven nature of the 'Notes' section provides a space for the user to add a qualitative layer of information to provide context to quantitative data and engage in a more reflective manner (Gao, 2012). This is however largely underutilised, partially due to the fact that it is so hidden in the interface design and the fact that it requires extensive manual effort from the user.
- The user-driven data collection process required by the MFP application (for weight, nutrition and physical activity information) implicitly demands a reflective stance from the user, generating opportunity for greater cognitive engagement in food and exercise choices, bringing mindfulness to these fundamental facets of wellbeing.
- Referencing the stage-based model for PI systems (Li, Dey, et al., 2010) the following cascading barriers are observed in the MFP system design:
    - Data collection stage: Accuracy of calorie consumption numbers relies on correct manual input by the user. For many reasons, without the use of spectrometer technology, 100% accurate input of calories is virtually impossible. Furthermore, due to complex psychological heuristics and biases, users tend to over- or underestimate their own performance (Tversky & Kahneman, 1974). This comes into play when users have to estimate portion sizes and calorie contents of their food choices. Furthermore, different data base entries for the same foods, indicate different calorie values. Likewise, different third party fitness PI systems used to track the exact same activity often provide dramatically different numbers for calories expended (see 1.4 – same workout tracked by both Strava and Garmin).

- Integration stage: If the user tracks a particular physical activity event using more than one partner third party PI system, multiple workouts are integrated and logged for the same activity, doubling or even quadrupling the number of calories indicated to have been burnt during the activity, significantly skewing the calorie goal (see 1.4 – same workout tracked by both Strava and Garmin).

These cascading barriers indicate clear probability for inaccuracy and lack of dependability of data, with potentially critical cascading implications on the stages that follow. This offers a clear example of how inaccurate data collection and / or integration can lead to disintegration/misinformation can lead to folly (Bernstein, 2009) or fat (weight gain) through counterproductive, undermining action, confusion and overconsumption, particularly in amateur users who over-trust systems and data (van Dijk et al., 2015).

2.5 Minding The Food Space

PI System	Platform/ Medium	Facets (Uni/Multi Faceted)	Driver – Data Collection (System/User Driven)	Driver – Data Integration (System/User Driven)	Dominant Style/ Design Strategy (Persuasive / Mindful Design)
Minding the Food Space ©	Paper-based handouts	Multi-faceted • Nutrition • Fitness • Mood	User- driven	User- driven	Mindful

Platform

Paper-based handouts

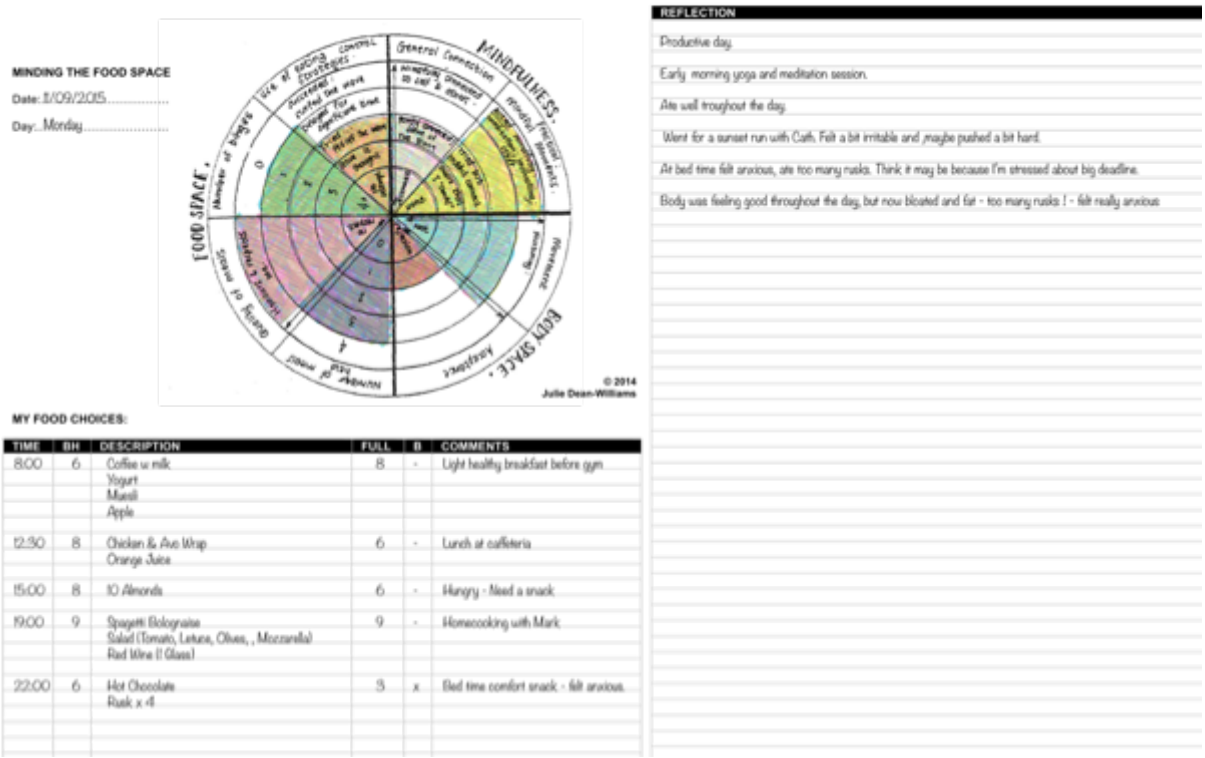


Figure 16: Minding The Food Space worksheet

Minding The Food Space © (MTFS) is a programme developed by therapeutic dietician, Julie Dean-Williams, offering mindfulness-based interventions to help people to cultivate healthier relationships with food, eating, their bodies and themselves. Various interventions are offered to assist clients in improving dietary-related cognitive and behavioural processes,

including individual therapy sessions, workshops, courses and retreats. As a part of these interventions, specific paper based methods are suggested for keeping track of food choices (food diary), eating related behaviours (for example, binging and purging), movement (exercise) and mindfulness practices, as well as subjective, qualitative aspects such as attitude towards body, connection to others, quality of meals and use of strategies taught in interventions.

Facets:
Multi-faceted

- Food
- Body
- Mindfulness

Drivers – Data collection and integration:
User-driven data collection
Food choices, related feelings, behaviours and attitudes are recorded manually (pen and paper) by the client in various prescribed formats including table, list and radar ('spider') graph format. Further space is provided for open written reflection and for additional context.

Dominant design style and strategies
Primarily mindful design style and strategies
The primary focus on qualitative food choices and subjective parameters implicitly encourages 'mindful' engagement. Tracking parameters specified (in both the food choices table and radial graph encourage mindful reflection, while the radial graph format and the resulting visualisation invokes subtly persuasive dynamics. In contrast with the MFP system design, MTFS has very light emphasis on numeric values, and does not include calories as a parameter at all. Numbers are indicated to be used by the client to subjectively score qualitative, attitudinal emotional measures, actions and behavioural tendencies.

The following section identifies key components of the MTFS paper-based interface that illustrate its primarily 'mindful' design style and subtle, complementary 'persuasive' design strategies.

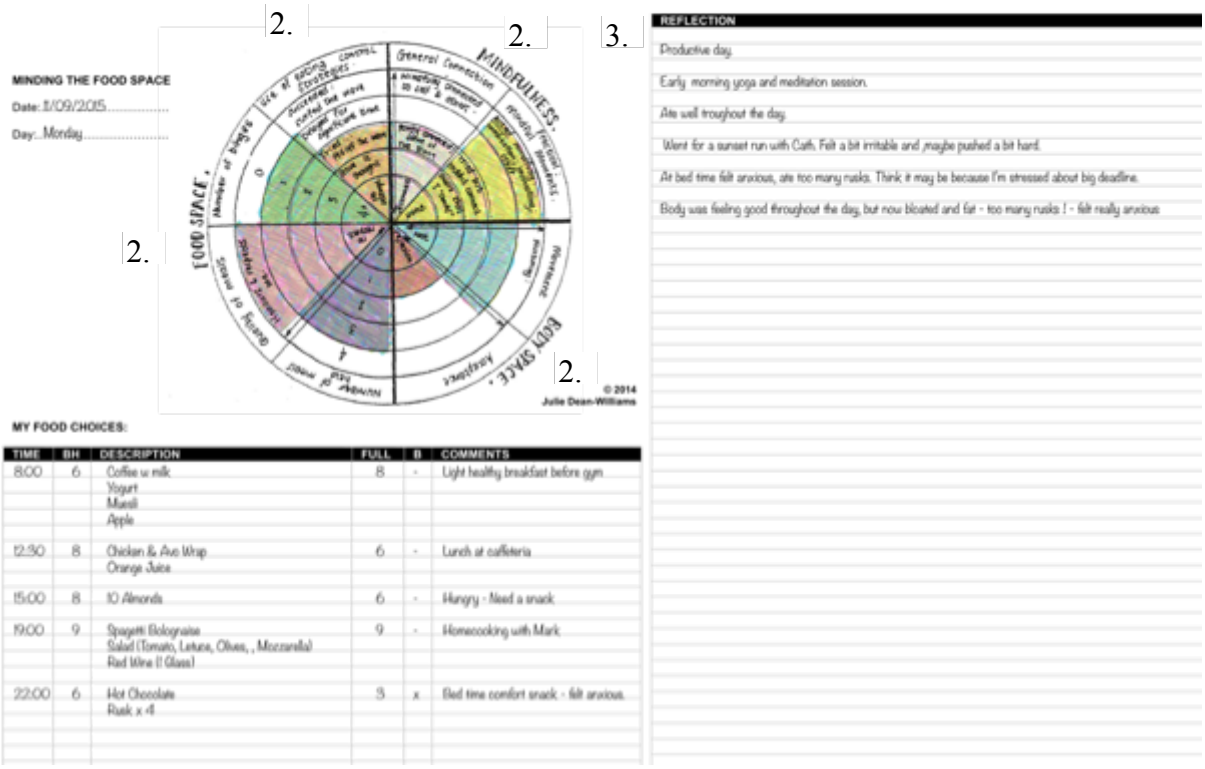


Figure 17: Minding The Food Space worksheet - Components illustrating 'persuasive' and 'mindful' design strategies and characteristics are numbered and discussed accordingly.

1. **My Food Choices** – This table contains six columns which prompt the user to enter specific parameters, i.e. time of meal, a subjective body hunger (BH) before eating score (1-10), a list what was eaten, a satiation (FULL) after eating score (1-10), an indication of whether the session was considered an uncontrolled binge (B) as opposed to a balanced and conscious meal or a snack and additional comments to add context to food choices.
2. **Wellness Web –** When filled in, this radial graph provides a visualisation of the client's daily subjective wellbeing, based on three broad categories, i.e. food, body and mindfulness. Each category is divided into segments which are further divided into hierarchical levels. The client reflects on his or her day and colours each segment according to how he or she experienced each parameter throughout the day. A fuller, more expanded radial graph indicates a better day, while an emptier, more contracted graph indicates a tougher day.
3. **Reflection –** This provides a space for any open reflection, to provide context, for logging feeling and personal insights.

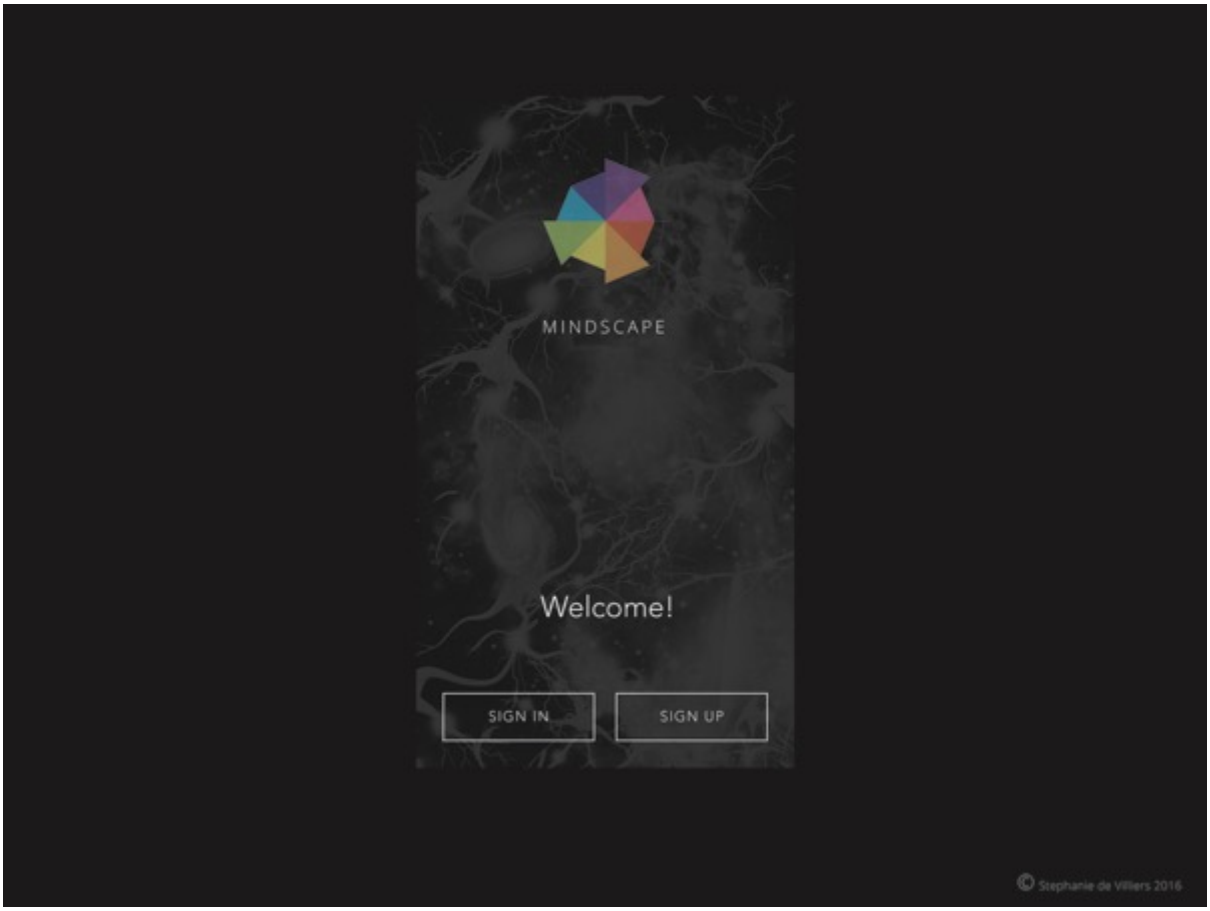
Persuasive and mindful design strategies:

The points above outline a primary focus on ‘mindful’ user experience strategies, with a subtle use of ‘persuasive’ strategies.

- Clients are prompted to reflect deeply on subjective experiences in order to fill in various parameters, ranging from assessing hunger and satiety, to general sense of connection with self to attitude towards the body. These dynamics encourage users to take a moment to become attentive to natural feedback mechanisms in order to generate deeper awareness, and ultimately make better decisions and take wellness promoting action.
- Users are further nudged towards engaging with their own data with the provision of space (and prominent placement thereof) for commenting on food choices and reflecting on behaviour, creating opportunity for gaining personal insights and for making sense of personal choices and behaviours.
- While encouraging reflection from users by the specific parameters and use of language, the wellness web further provides a gently persuasive tactic in the form of a holistic wellness goal tracking visualisation. One could argue that this taps into BE principles of Commitment and Ego which imply that users are motivated by performance, a subconscious driver will thus be to be able to provide a fuller, more expanded version of wellbeing, thus providing an intrinsic incentive for behavioural change.

MTFS provides a powerful example of an artful balance between mindful and persuasive design, where persuasive strategies support reflective engagement.

APPENDIX C: MINDSCAPE
PROTOTYPE AND BUSINESS MODEL PRESENTATION



RESEARCH TITLE

The observing self as a catalyst for behaviour change and wellbeing

Effective design of personal informatics systems
to promote behaviour change in the changing health paradigm

RESEARCH PREMISE

A key question within the connected health care movement is whether personal health data can support lasting behavioural change and more enduring states of wellness.

A plethora of invasive, persuasive technology and extrinsic motivators can promote disconnect and disintegration of self and collectives.

However, encouraging behavioural change through reflective system and UX design can be powerful in cultivating internal motivation for behavioral change and better wellness.

RESEARCH

Primary Question:

What are the qualitatively different ways in which people experience personal informatics systems that promote behaviour change for improved wellbeing in the context of the changing health paradigm?

Secondary Question:

How are established principles of behavioral economics and mindfulness applied and incorporated in the design of self-tracking agencies (systems and programs)?

Methodology:

Phenomenography

Methods:

User and program administrator interviews and analysis

THE
MINDSCAPE
INSTITUTE

THE MINDSCAPE INSTITUTE

MISSION:

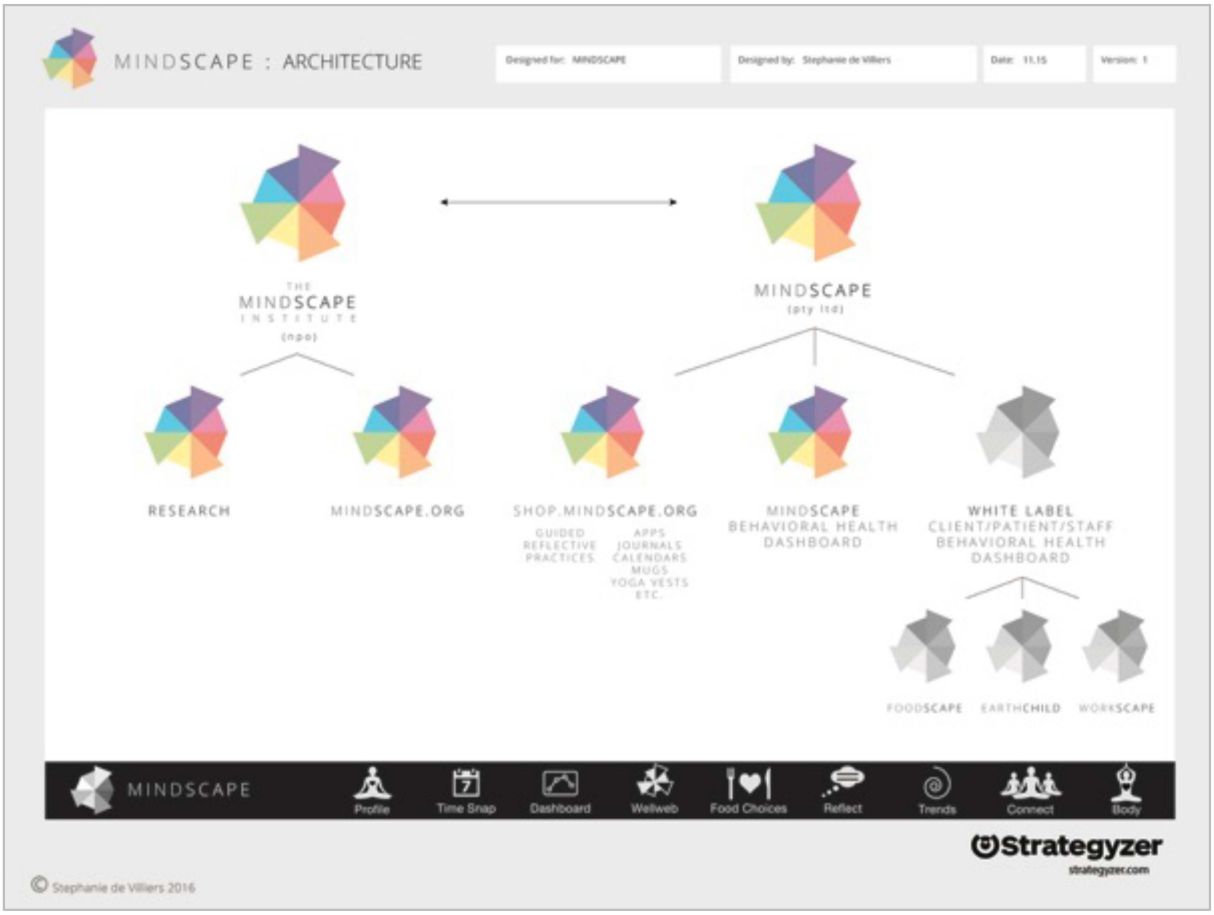
To support wellness of users
by leveraging the power of persuasive and reflective positive technologies
to create intrinsically rewarding experiences.

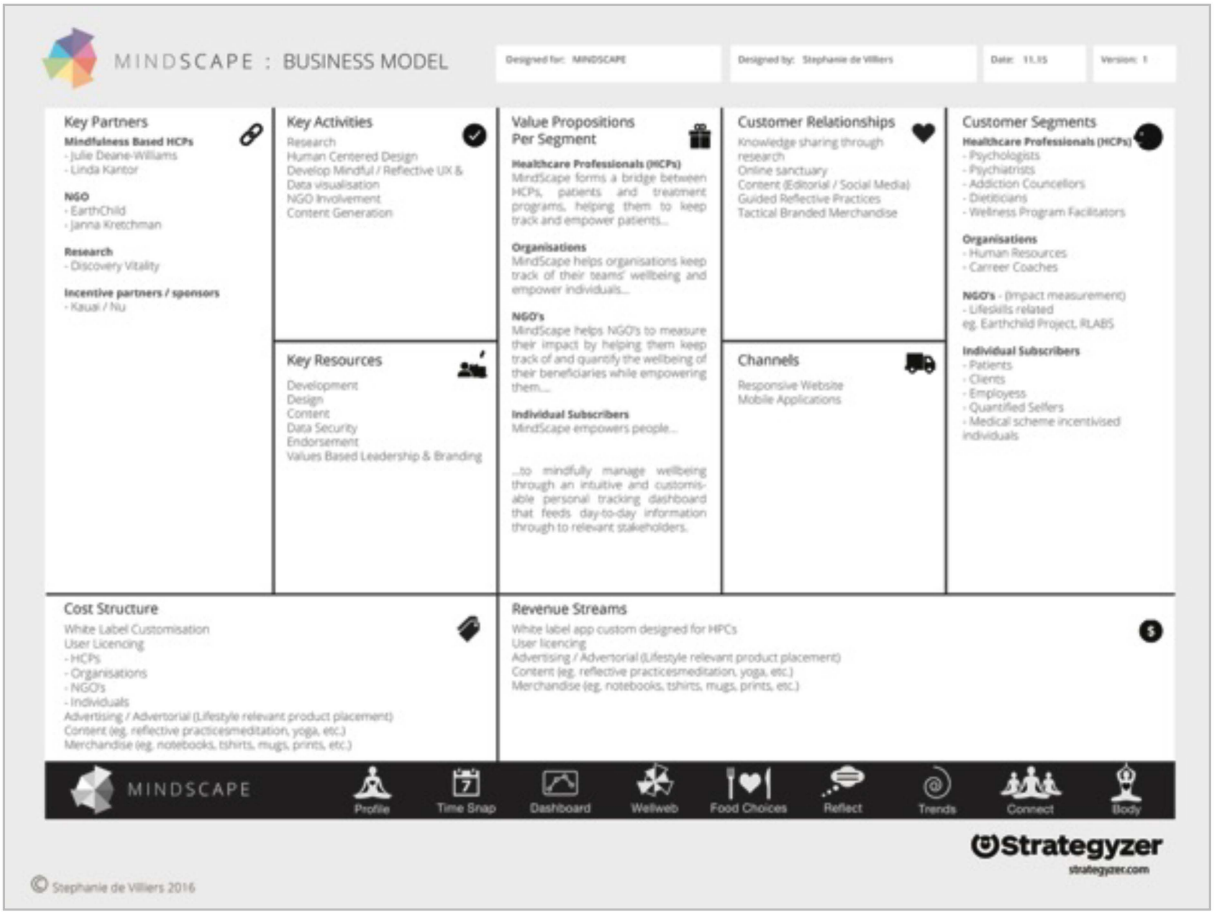
VISION:

Create a user base of healthy, intrinsically motivated, mindful individuals who feel competent, autonomous, and connected

VISION:

Personal Accountability / Responsibility
Adaptibility / Flexibility
Truth & Transparrency
Ahimsa (Non violence / Do no harm)
Personal Power





PROTOTYPE V. 1 : WHITE LABEL

FOODSCAPE

PROTOTYPE V. 1 : FOODSCAPE

Human-Centred Design Process

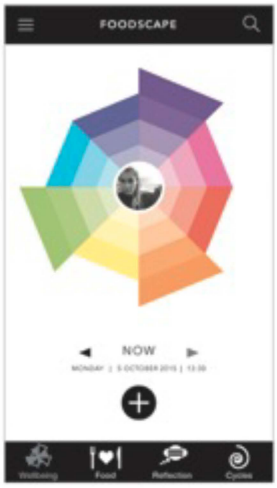
Healthcare Professional Collaboration
Designed in collaboration with mindfulness based therapeutic dieticians,
Julie Deane-Willams & Emma Baty

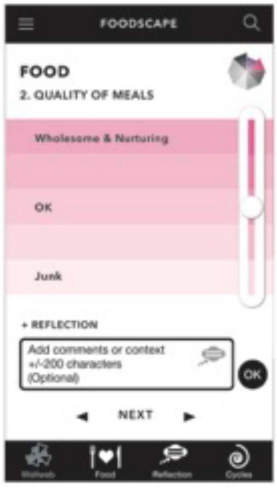
Patient / User Interviews:
Patients
Individuals that match patient profile
Personal experimentation

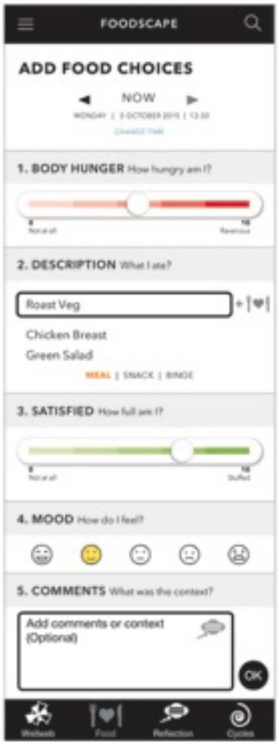
Overwhelmingly enthusiastic responses and positive feedback and
"When can we start using it?"

PROTOTYPE V. 1 : FOODSCAPE

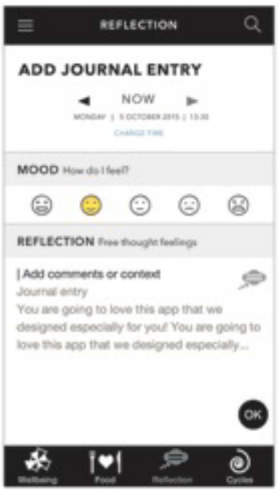
PROTOTYPE V. 1 : FOODSCAPE

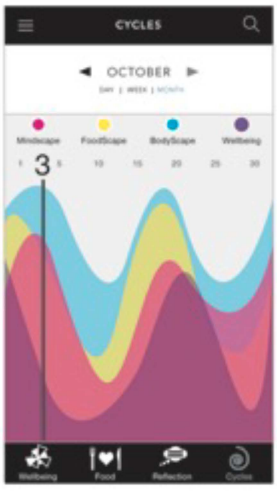






PROTOTYPE V. 1 : FOODSCAPE





THANK YOU